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Changes in Street Lighting.

Adequate provision for lighting roadways is a matter constantly before municipal authorities and their various departments. Few cities have really well-lighted streets save within a very limited territory. Looking at the matter from the standpoint of the engineer the proper illumination of streets is a difficult matter on account of the large area, the generally dark tone of the surroundings, and the limitations on position of lights imposed by trees. In the old times when streets were lighted mainly by gas, it was really difficult to get enough light in a street to make much impression upon the gloom. The coming of the electric arc made a great improvement. Lighting was bettered then along two lines. First, the gas lights were replaced by powerful arcs; second, to a more limited extent, electric incandescents replaced gas lights, practically lamp for lamp. The two systems have survived, but the arcs being much cheaper per unit of light found general preference. In the beginning prices for arcs were, however, high and their power was overestimated so that it came about that in the interest of a somewhat spurious economy they were too widely spaced. Arc lights in this country are placed generally 200 to 300 ft. apart, or even more, with the result that the illumination midway between them is too low, while the early arcs in particular gave a quite needless brilliancy immediately about them. The coming of the enclosed arc has improved this condition, but still leaves a very considerable irregularity, so that, looked at from a little rise, the ordinary street presents the appearance of a series of bright bars separated by black blocks. From a nearer view the arcs are altogether dazzling, and produce a sort of wall of light almost impenetrable to vision. Those who use motor cars realize the common faults of street lighting perhaps better than any others, and feel more keenly the need of better distribution of the illumination. A street really well lighted by incandescent lamps is better lighted for ordinary purposes than one lighted by arcs in the usual way, although the apparent brilliancy in general effect is lost.

Within the last year very considerable improvements in the materials of street lighting have been made and should be impressed on municipal bodies having lighting in charge. In the first place a new form of incandescent "series" lamp has been introduced which gives as much light as before on the expenditure of about two-thirds the energy. Hence such lights can be, and are being, more cheaply furnished. On the other hand, new arc lamps are coming into use which give a similar gain in the energy required. While these have not yet settled into a standard form they have reached a point where they must be seriously considered. One form of the flaming arc, which gives a specially good outward distribution of light, and hence increases the uniformity of the illumination, has already been adopted by a number of cities, with improvement to the lighting and material reduction of cost. Still other improvements are on the way. This is the time, therefore, to put in a strong plea for improved street illumination. A freer use of the cheapened incandescents will make it possible to give much more uniform lighting of the many streets where trees interfere seriously with lighting by arcs, and the improved arcs, within their appropriate sphere, will enable our streets to be effectively lighted all over with less unnecessary and indeed, harmful, local brilliancy. To secure these benefits local authorities should take advantage of the improvements, not to lower the lighting appropriation, but to light the streets on a more liberal scale. Every city presents many localities in which lights are now so infrequent as merely to exaggerate the darkness between them. These are the places in which to employ the saving made on account of more efficient methods. A careful study ought to be made of the situation and new lights located where they will fill the gaps. Again, one often finds points at which arcs can profitably be replaced by incandescents or vice versa. The whole matter has in the past been too generally taken up in a haphazard sort of way which has resulted in both real waste and false economy. Now, when new and cheaper methods are becoming available, is the time to correct former mistakes and to start afresh. The ideally lighted street is the one in which people can see plainly and easily without being dazzled by violent contrast. To secure this result, on the whole, more lights, and lights giving better distribution are needed, although the actual energy required may remain the same. It is both bad judgment and poor economy to save light and promote accidents, when really effective illumination is easily obtained.

Standardization in Civil and Mechanical Engineering.

It would be interesting to know if the advocates of standards for all purposes have ever reflected that a rigid adherence to their fetich would have left us with a Concord stage and clipper ship as the best facilities for transportation and puritanic blue laws as a code of municipal conduct. Standardization is an admirable thing, but so is an intelligent departure from it when occasion warrants. The sensible innovation of to-day is the standard of to-morrow, and always will be, and any attempt to check the rational development of engineering work by asserting that it is an unwarranted departure from standard practice or machinery deserves only careful attention and not blind acquiescence. The substitution of mild steel for wrought iron for structural purposes, the growing use of steel castings and the adoption of concrete in place of other forms of masonry are examples of departure from standard practice in civil engineering work which have been the subject of prolonged discussion in the past, just as the introduction of steam turbines, electric drives and large gas engines has stirred up conservative mechanical engineers.

In looking over the progress in both branches of engineering in the last quarter century, it will be noticed that it has really been along a very few lines. While novelties without number have been proposed, those that were successful have been few, and their success was only demonstrated when they were developed by men of engineering ability backed by clients who were confident that the lead of these experts could be safely followed. This fact is the most important one for a man to consider who is asked to adopt some innovation; it is also the most important one for the engineer to consider when he urges a departure from accepted practice, for if this departure fails he will lose a considerable measure of his reputation as a safe guide in technical matters. Just at this time, when there is plenty of money for new ventures that are promising, there is a manifest tendency to try too many new things, to depart from standards without fully considering the desirability and practicability of the departure in all its aspects. When shops are rushed to supply regular materials and equipment is the very last time to select for bringing out something new, because the strain on manufacturing facilities in the regular course of business will prevent attention being given to the advantages of the suggested innovations and they will be opposed for commercial reasons by the very people most likely to encourage them when production is slack. In the same way the civil engineer who departs from regular practice, either in calling for special materials or adopting designs which will be difficult to execute without specially training a large force of workmen, is running the risk of causing his client a very large expenditure. It is the general observation of civil engineers that at times when labor is highly paid and in great demand and materials of construction command high prices, as at present, the difficulty and expense of introducing departures from standard methods of construction are particularly marked.

The truth of these facts is evident from a consideration of the civil and mechanical engineering work of the last two years. Although it has been a period of unprecedented activity in both branches of engineering, there have been comparatively few departures from standard methods, not because there has not been an opportunity for them, but because the specialists who could safely make them have recognized that they were not financially advisable. The most marked steps forward have been taken very carefully and only after thorough investigation by men whose ability to decide upon their merits is acknowledged fully. The only serious departure from this general condition has been in the field of concrete construction, where people without technical ability have attempted to work wonders and have failed. These very failures lend emphasis to the point that anybody who puts out his money on such variations from methods of construction approved by experience is likely to think long and bitterly of the old saying about the speed with which a fool and his money are parted. The departure from standardization is a praiseworthy step when it is warranted, but it should never be made except with the advice of somebody whose experience and judgment fit him to be a safe counsellor. For most purposes an acceptance of standards is the wisest course by all odds.

The Influence of the Engineer.

Elsewhere in this issue will be found an address on the engineer as a citizen, delivered last week at the dedication of the new engineering building of the University of Pennsylvania, by President Humphreys, of Stevens Institute. It is to be heartily commended to those who wish an explanation of the reason why engineering must eventually rise to a place of great prominence in our national life. It can also be read with profit by those who have shipped a cargo of technical data and wonder why the public does not crowd up in eager haste to buy. Probably no clearer statement has ever been made of the reason engineers are still looked upon as a new class whose position has yet to be determined. The delay in according them the rank their responsibilities deserve has not been because they dispute among themselves over details of their work, for so do physicians and lawyers, nor because their work was not of great public and private importance, for it is admitted that this is the age of the engineer's pre-eminence. The explanation is to be sought in the reticence of the engineers themselves. They have hesitated to take part in the discussion of engineering subjects of a public nature lest they should be considered as seekers after engagements for themselves, and they have been content in private undertakings to remain merely technical men and have not reached out to grasp the executive places they were fully able to fill. This condition must be changed, and by the engineers themselves, for reasons that are pointed out in the address mentioned.

It is a melancholy fact that anybody who waits modestly in the background for somebody to discover his importance is likely to be overlooked. The people who do not acquire useful knowledge and then make that knowledge useful by insisting on applying it to some good end are like cabbages, valuable enough in themselves, but not deeply influential. In our form of government each citizen is under the deepest obligation to take part in public affairs and to prove himself worthy of the advantages which the founders of the republic sacrificed themselves to secure for their successors. On this supposition the engineers should occupy the most influential position in public life of any single class, for their advice is most needed. Our legal systems are well established, and the value and dignity of the medical profession are everywhere recognized, but the importance of engineering is just beginning to be appreciated. It is true that the Pennsylvania Railroad Co. has been managed for many years in most branches by engineers, and owes most of its present foremost position to the fact that the men in control had the technical information as well as business ability necessary to plan successfully far into the future. It is not so generally understood that this is practically the unwritten policy of the United States Steel Corporation to-day, which is rapidly advancing its young engineers who show business as well as technical merit; an instance of this was shown but a few days ago when a graduate of the Massachusetts Institute of Technology, a young man thirty-three years of ago, was made president of the latest great subsidiary company of this corporation. This practice among private companies naturally precedes the same course in public affairs, where the conservatism which considers business men and the political methods which permit only workers to be eligible for administrative offices have retarded the correct management of public undertakings. And yet to-day, in New York, where politics and business influence have controlled most elections and appointments to executive offices for some years, the borough where the taxpayers are getting the best return for their expenditures on public works is Richmond, whose Commissioner of Public Works is a consulting civil engineer.

It has been said that the reason the engineer is specially fitted for administrative offices is because his calling makes him a student of the truths of nature, and these studies naturally react to make his character and particularly his judgment upright and impartial. This sounds so nice that a good many people have been repeating it without stopping to reflect that it is not so. The reason the engineer is to occupy a commanding position as soon as he gets breadth and executive experience is because his technical knowledge is just the information that, coupled with business ability, is needed to-day at the head of our manufacturing industries and public works. Just so long as the engineer is content to be a mere technical man, he is not only losing his greatest opportunities for individual advancement, but he is also paying no attention to the obligations imposed upon him as a citizen. His technical education has been conducted along a narrow rut in the past, and his backward position is due in a measure to the failure of the technical schools to make their students understand their public duties. For his protest against this narrow education and for his appeal to engineers to come out of their shells and take up the duties of citizenship, President Humphreys will have the hearty applause of all those who have been studying the trend of economics in this country.

The Reform in Teaching Mathematics.

During the last two or three years there has been a rather remarkable agitation in regard to reform in the teaching of mathematics, due as much to Prof. John Perry, of London, as to any other one agent or influence. This agitation has been productive of substantial results, and no small service has thereby been rendered especially to the education of engineers. This movement has not been a simple agitation, although it has been accompanied necessarily by much discussion in many quarters. Substantial changes have been made in the manner of mathematical instruction in both Europe and this country in consequence of it. The old motive of mere demonstration as an exercise in abstract mathematical operations has largely been displaced by the much more rational and effective system of exercising the student's knowledge by its actual application to useful things. Even England, which has been the uncompromising stronghold of Euclid, has largely abandoned the Euclidian geometry and adopted what may be termed modern geometry. Precisely the same general observation may be made in regard to much of the mathematical teaching on the Continent, where instruction in geometry has taken a far more concrete and useful form than the old system.

A careful consideration of this subject of mathematical instruction can scarcely fail to lead any open mind to the conclusion that there can be no better test or exercise of knowledge than the student's capacity to use it. This is pre-eminently applicable to engineering mathematics as given in courses of engineering study in this or in any other country. The engineer's profession is an intensely useful occupation. It deals wholly and directly with many of the most well-defined realities or practicalities of life. While the general trend of an engineering student's studies should be systematic and rational above all things, the system and rationality should be brought to bear not upon the abstractions of mathematical work, but upon their applications to the physical problems of which the greater part of his professional work is to consist. Nothing is more marked in the experience of an engineering instructor than the fact that a student may frequently be thoroughly familiar with the complete mathematical demonstration of a theorem or formula and yet be incapable of applying it properly to the simplest engineering problem, involving the ordinary units and quantities of engineering practice. Indeed, it has been stated that mere familiarity with the mathematical demonstration of a formula gives it essentially no value to the student, and the statement is true. The student needs imperatively a familiarity with the nature and relations of the concrete things entering into his formula or theorem. Without a thorough familiarity with these elements, the formula has no meaning to him, and he is without the power of application.

There are actually many hundreds of engineers in practice at the present time whose chief exercise in the technical school where they were educated lay in topical demonstrations of mathematical formulas without the first intimation of any practical application of them to engineering work. This was true of the whole range of such broad subjects as the theories of earth pressure and the arch, the resistance of materials, hydraulics, and indeed every professional topic covered by a course in engineering study in the old days. While much of this is radically changed at the present time, it is well for engineering instructors as well as for those engaged in pure mathematical work to give most thoughtful consideration to this broad subject of mathematical instruction. There are instructors, and those among the most prominent and successful, who have practically abandoned the requirement of mere demonstration of abstract mathematical formulas. They dwell upon those demonstrations sufficiently to indicate to their students the rationale of the various steps involved in them, but they concentrate their main efforts of instruction upon the practical exercises of the students in the application of formulas to concrete problems. In courses of engineering instruction the problems should be entirely those which are met in engineering practice. There is no higher grade or more efficient line of instruction work than this. It is practically impossible for any student to apply any formula to a problem of engineering design or of engineering investigation, in any direction whatever, in a correct way so as to give the necessary results, without becoming intimately familiar with the logical meaning of every quantity with which he deals. In fact, he can acquire such familiarity and intimate knowledge in no other way whatever. The possession of such knowledge is precisely that which differentiates him radically from the mere handbook engineer, who uses a formula as a rule of thumb, and is as likely to make a radical error as to obtain a correct result, if, in fact, he is not much more likely to do so.

Although this reform in mathematical instruction probably had its initiative largely in the purely mathematical field, vigorous efforts in its extension have most properly been exercised in connection with engineering instruction. This is most fortunate, and while much has been accomplished, engineering instructors can render no greater service in the line of work they are doing so effectively for the engineering profession than to push on earnestly and energetically until the whole body of instruction in engineering mathematics has been put upon the sound and rational basis of application to actual engineering work.

The Railroads and the Mining Industry.

"I venture to think that none of us—miner or metallurgist—will often be driven to take advantage of any of the useful but drastic clauses of the rate bill, which both houses are so busy framing for our benefit. If we have a grievance it will be easier to make the railroad traffic manager understand it and induce him to apply the remedy than to explain the intricacies of our case and depend for relief on a commission in Washington." These words form part of an address by Dr. James Douglas, at Columbia University, on some of the relations of railroad transportation in the United States to mining and metallurgy. It is safe to say that an examination of the results of the skillful adjustment of rates by railways to the needs of this great industry will show that anything tending to fix schedules permanently is likely to affect the mining and metallurgical interests of the country. For example, the mines at Globe, Ariz., languished for lack of sulphur and iron flux for a considerable time, and could barely make a million pounds of copper a month. As soon as the railroads learned the needs of the miner they published a low ore tariff, which enabled pyrites to be imported from distant districts where it is in excess, and as a result the production rose rapidly to three million pounds a month. These low rates were given by the railroads because they knew that the industries built up by them would support a population which would in turn require supplies paying a higher rate. It is this knowledge which leads many large companies to have industrial departments whose sole business it is to see what can be done legitimately to foster manufacturing and mining along their lines.

The vital importance of transportation in mining and metallurgy may be shown by other examples. For instance, Dr. Douglas stated that at the Copper Queen works in the early days the cheapest coke was brought from Wales around Cape Horn in grain ships to San Francisco. It cost more than three times the price at which New Mexico or Colorado coke is now delivered after a railroad haul of eight hundred or a thousand miles. Coal for steam generation was then so costly that the country was swept clear of its scanty accessible forests. Crude oil is now brought in from Texas and California at a freight rate not exceeding three-quarters of a cent per ton-mile, so that at one smelting works in Southern Arizona, 700 miles from the nearest source of coal and oil, power is generated, according to Dr. Douglas, at a cost for fuel, maintenance and all expenses of $79 per ton per year. The effect of transportation on copper production is particularly noticeable because the ores run so low in valuable metal that even after water concentration about twenty tons of charge have to be smelted to yield one ton of copper. It is for this reason that the fuel must be taken to the ore, and not vice versa as in the iron industry, and if the railroad officials did not recognize this fact in their rates Montana and Arizona would not be turning out one-third of the world's production of copper. It is not only in respect to fuel, moreover, that this branch of metallurgical work depends on transportation, for the crude product of the smelters must be shipped two or three thousand miles to be refined and marketed. It is even possible, under the low rates which railroads make, to ship copper matte from Tennessee to the interior of Mexico, use it there to collect gold and silver from dry ores in the furnace and converter, and then reship it for electrolytic refining and separation in the United States.

Even in the case of the iron industry, where only two tons of raw ore are needed for a ton of iron as compared with forty tons in the case of copper, transportation assumes great significance. Last year the United States Steel Corporation required 18,500,000 tons of Lake Superior ore, probably 22,000,000 tons of coal and 4,000,000 tons of limestone, at least half of which must have been hauled over a thousand miles; it turned out 10,000,000 tons of finished products which were doubtless distributed with a shorter average haul. The pig iron output of other companies exceeded that of the Steel Corporation about one-third, so it can readily be seen that the railroads play a vital part in the success of this great industry.

These facts were not given by Dr. Douglas, nor are they repeated here with the intention of criticising the views of the President or the acts of Congress, but simply to point out the close relation which exists between transportation and the metallurgical industry. It is a subject which the engineer is particularly well able to comprehend, and one which it should be his duty to state clearly, lest an essential part of our industrial system be damaged by ignorant tinkering. There have unquestionably been abuses of rates by railroads and favored shippers, but it is ridiculous to claim that the only way to remedy this evil is to bind up the managers of the railroads by a code of rules which will react to the great detriment of all our great industries depending on supplies of bulky low grade raw materials obtained from a distance.

Notes and Comments.

The Pollution of the Schuylkill River is receiving the attention of Dr. Samuel G. Dixon, Health Commissioner of Pennsylvania, who has found and eliminated about 1,500 minor sources of contamination of the water. The discharge of sewage into the river by cities will be more gradually reduced, as it is necessary under the laws regarding stream pollution to wait until cities apply for permission to enlarge their sewerage systems before compelling them to purify the sewage. It also seems probable that the city of Philadelphia will endeavor to secure legislation before long compelling private interests and cities to stop polluting the stream with manufacturing wastes and refuse from coal mines.

The Large Tunnel Contract shortly to be let by the Board of Water Supply of New York, of which details are given in the Current News Supplement of this issue, is the first piece of construction to be announced by the Board. The fact that plans and specifications have been prepared already for any part of this great undertaking is proof of the extraordinary speed with which the work is being pushed, nothing approaching it having ever before been accomplished in municipal engineering. Unquestionably this record is due to the wisdom of the Board in selecting a chief engineer with a high reputation for getting things done on time and properly, and giving him all the expert assistance in both consulting capacity and salaried staff that he needs. It is only in this way that an undertaking of such great extent can be carried through to a successful completion. The work is of such enormous cost and extends over such a long strip of territory that not only the department engineers but also the division engineers must be men of experience and judgment, able to act on their own initiative in the management of portions of the construction which will equal in cost the money spent for the entire public works of many cities of large size.

The Collapse of a Grandstand at Syracuse on October 20, while it was crowded with people watching a football game was fortunately not so serious in its results as might be expected. Although about a hundred people were more or less bruised and shaken, only three were so badly injured as to render their recovery problematical. The grandstand was a wooden affair about five years old, probably like hundreds more in the country, which are safe as long as every part is strong and in place, but as unstable as a house of cards when anything breaks. There were probably a large number of spectators at this particular game who were competent judges of the strength of such a structure, yet it is safe to say that none of them looked to see if it was able to carry the weight of the dense crowd on it. It is well known that the average grandstand is to be regarded with grave suspicion, yet there seems to be no attempt made to ascertain in any case whether it is safe to allow people to crowd into them. In view of the frequency of such accidents and their serious danger, it may be urged that college authorities are not discharging the full measure of their obligations if they fail to investigate the safety of these grandstands and bleachers which are packed with their students during intercollegiate games.

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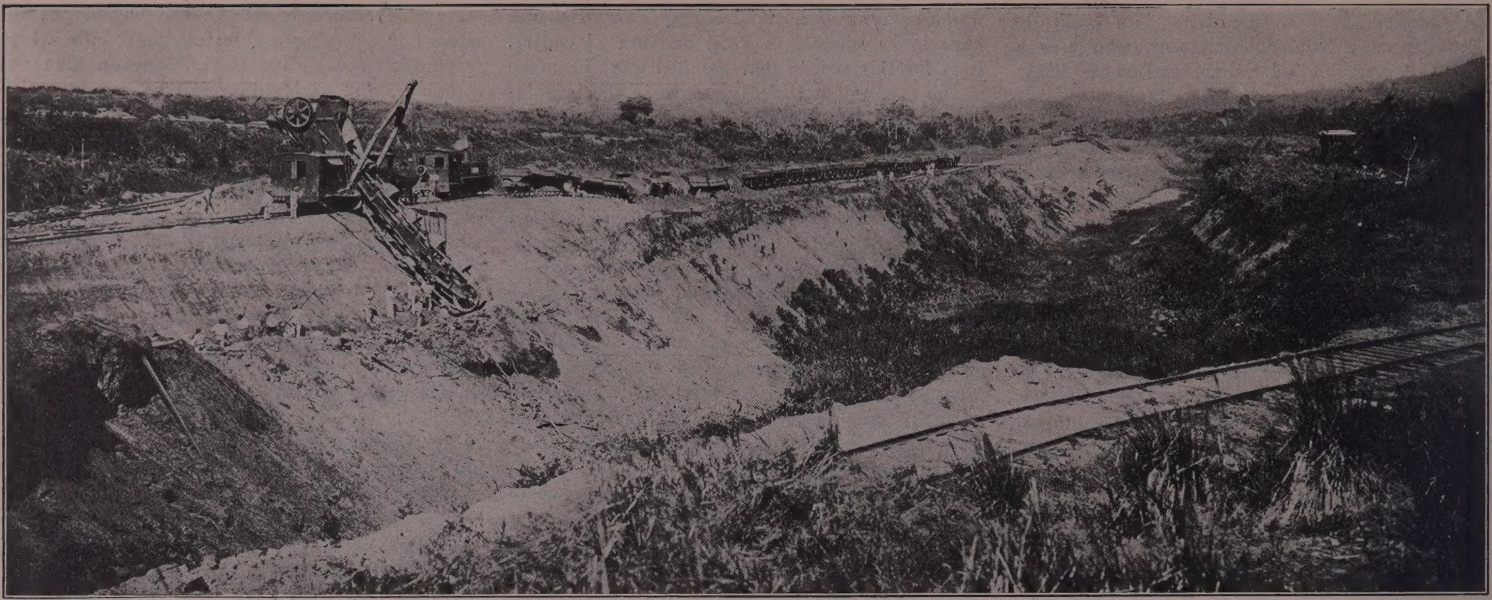
The Services of a Consulting Engineer in connection with garbage disposal problems are likely to be of special value for reasons that do not often suggest themselves to city officials. It is a comparatively easy task for a man of average engineering ability to design a crematory which will burn municipal refuse and garbage fairly well for a few months, and, in fact, last several years under some conditions of use. The Patent Office Gazette contains records of large numbers of such furnaces, which have been the source of proud hopes to their inventors, and only too often of bitter disappointment to purchasers. It is safe to say that any shrewd board of public works can prepare a specification for one of these crematories which will give the city a furnace of adequate capacity for some months, long enough for the contractors to be paid for it. The defect of engaging in such a contract without the advice of a consulting engineer lies in the omission in the board's specifications of clauses rejecting unimportant details on which patentees lay undue weight, and neglect to call for others of technical merit; in other words, the customary contract is for a plant of a temporary character, while a competent consulting engineer will call for construction of a more durable character. Another warning should be given to city officials interested in this subject; there are one or two individuals posing as disinterested experts on garbage disposal who are really agents for patented systems and in selecting a consulting specialist care should be taken to avoid engaging a prejudiced salesman as an unbiased adviser.



View in the Culebra Cut While Experimenting With a French Ladder Excavator, Locomotive and Six-Meter Dump Cars.

MECHANICAL EQUIPMENT OF THE PANAMA CANAL.

By Charles W. Burke.

The recent settlement of the long-debated question of the type of canal to be built across the Isthmus of Panama has ushered into active interest the choice and installation of the mechanical equipment for this vast enterprise. The efforts of the Commission to utilize, as a matter of economy and expediency, the old French machinery have brought out many interesting comparisons which, in spite of the time lost and inconvenience suffered in securing the data for them, have proved of inestimable value in the matter of selecting new machinery for conducting this work. Prior to the time the United States assumed control of the canal property, the only operations being conducted in the way of actual digging were those directed by a company of French engineers with several thousand men. This body of men was engaged in excavating Culebra Cut simply to hold the company's franchise. Of the enormous amount of valuable machinery deposited on the Isthmus by the original French company, only a very small percentage was being utilized by this second company.

The equipment included 240 Belgian locomotives of small capacity, self-contained with tank and coal space, varying in size from 15 x 20 in. to 16½ x 24 in. A large percentage of these locomotives had never been completely assembled for operation, and were found standing in the midst of tropical growth on temporary tracks and completely covered by the vegetation. When abandoned by the old company all bright parts were protected by coating them with white lead and tallow. In the case of those located away from either sea coast, no rust was detected after eighteen or twenty years standing. All these locomotives have copper fireboxes and white metal tubes. The French before abandoning them filled the boilers with water, and after putting in a half barrel of oil allowed the water to escape, thoroughly coating the interior with the oil. They were then sealed up and left to the mercy of the elements.

Some of the locomotives were connected up and utilized for the time being until more modern machinery could be obtained from the United States. The tractive power of these Belgian locomotives is from 11,000 to 12,000 lb. each, and as grades were necessarily heavy, 1½ to 2½ per cent., and increasing as greater depths were reached by the excavating machinery, the tonnage in dirt handled was so small that it created too great a train movement and too large a unit of expense. In their place arrangements were made to secure 144 locomotives of the Mogul type from the United States, 100 with cylinders 19 x 24 in., and 44 with cylinders 20 x 26 in. The first 100 are for use in handling trains and serving steam shovels in the canal prisms, while the latter 44 are to be used on longer running hauls to the dumping grounds.

As the movements of these engines is both backward and forward a long, low, sloping type of tank has been adopted to avoid obstructing the view of the engineers as much as possible. A large percentage of the new locomotives are delivered on the Isthmus completely knocked down and have to be erected by the canal forces. So efficient, however, is the mechanical organization that in an incredibly short time the locomotives thus delivered were completely assembled and in active service.

There were also found abandoned by the French company about 3,900 French and Belgian small dump cars of from 5 to 8 cu. yd. capacity, which gave fairly good service, but were entirely too small for modern steam shovel work. These cars were not of sufficient strength to withstand the impact of five and six-ton rock that are now being handled by the 5-yd. dipper steam shovels.

The land-excavating methods employed by the French were various, the principal one being side excavation with buckets. The excavated material was elevated in buckets to the dumping cars, entailing undue waste of time and energy. This method possessed the added inconvenience of requiring a third rail on the excavating side of the dump car in order to maintain the balance during loading. To overcome this the French later designed a number of machines which they called "hill diggers," in which the

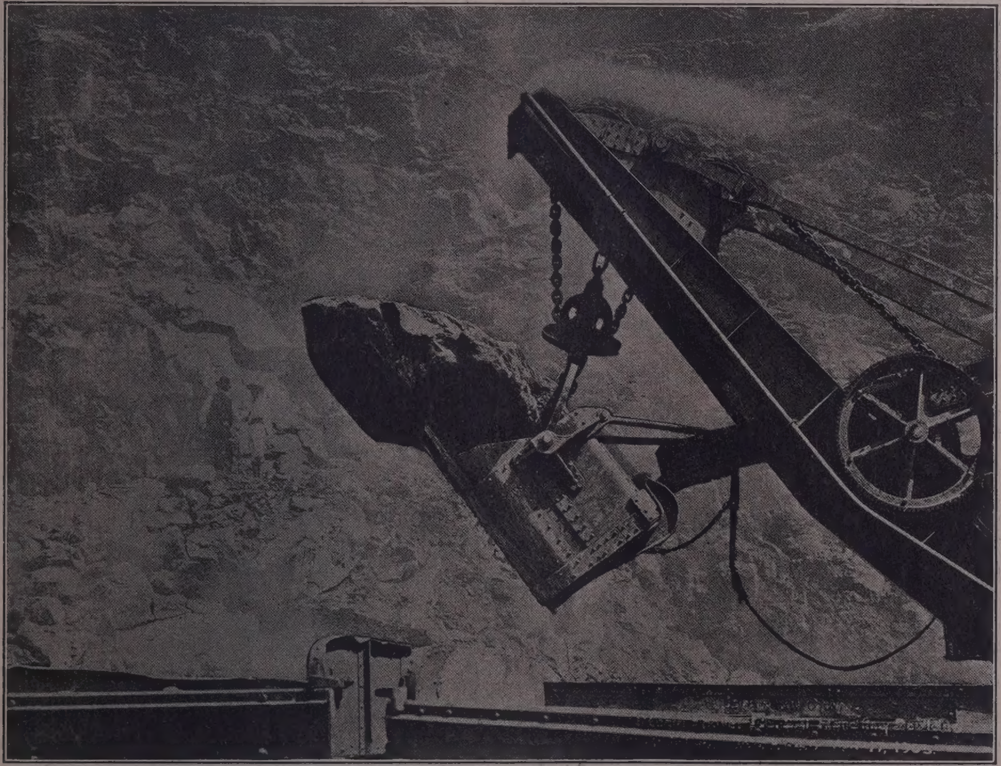
Under the Palms at Cristobal, Canal Zone.

French All-Metal Track in Culebra Cut.

arm carrying the excavating buckets projected above the body of the excavator and was so manipulated as to force the buckets up against the side of the hill. The contents of the buckets were then carried along the arm and deposited in the dump cars on the adjoining track.

About 250 rigid-boom swinging derricks formed a part of the abandoned machinery. These were of four tons capacity, and of English, French and Belgian manufacture. The French used these machines by placing one above the other on terraces. One-yard buckets loaded by hand on the lower level were raised from one derrick to another, finally depositing their contents into dump cars on the uppermost terrace. This proved to be a very slow and tedious method.

Cableway outfits extending across the canal prism were also employed in the general elevation of material. Buckets were loaded by hand, raised and conveyed in or out to dumping cars. Although a considerable improvement on the foregoing methods, it was also found to be too slow and costly, considering the magnitude of the work to be accomplished.



Typical Bowlder Being Handled by Steam Shovel in Culebra Cut.

All of the methods used by the French, together with hand loading, were thoroughly tried out under the American administration, and the actual cost per cubic yard of each method determined. It was then seen that methods capable of excavating and handling of material on a much larger scale must be adopted. American steam shovels having dippers of 3 and 5 yd. capacity were accordingly ordered, and are now in active service.

As a substitute for the French dump cars a thorough test was made of a large number of the various types now in use in the United States, but as regularly arranged, they were found to fall short of meeting requirements, principally for two reasons. One was that in the earthwork the nature of the material is such, during the long rainy season, that the existing angle of slope of the dump cars was not sufficient to allow the material to unload freely, requiring a large amount of labor for hand cleaning, not desirable in securing low unit cost. The other reason was due to a special feature of the rock work. The present steam shovels are handling rocks varying from 30 to 50 in. across the largest diameter, as shown in an accompanying illustration. The existing types of dump cars did not admit of sufficient clearance between side doors and bodies when dumped to allow for passage of this size rock.

As the principal part of the excavating work in the main cut will be done in rock, such a condition had to be provided for in another way. It was decided that handling rock on flat cars utilizing side-unloading plows was most feasible. Wooden flat cars of 40 ft. length were then ordered, each arranged with gondola sides 3 ft. high on one side, and on the other side, instead of stake pockets, brackets were substituted on which the car floor on that side is extended 15 in. beyond the side of the car. This extension answers the double purpose of partially counterbalancing the excess side loading, caused by the heavier weight on the opposite side allowed by the high planking, and also, when unloading by the plow of carrying the excavated material further away from the rail. This improvement was made to overcome the former difficulty brought about by the excavated material banking up against the trucks of the cars offering such resistance to the train movement as to entail considerable loss of time and energy. About 1,000 of those cars have already been delivered on the Isthmus. The dump train is immediately followed by "spreaders" distributing the excavated material uniformly over the adjoining land, leaving the dumping ground in shape for the next loaded train.

The side-unloading plows had to be specially designed for the canal work. This was made necessary not only on account of the unusual width of the car, but also of the added strength required owing to the heavy nature of the material to be moved. In pulling this plow over the train by the unloaders it was found that the 25-ton engines were not of sufficient capacity for the work, so unloaders with a cable pull of 60 tons were arranged for.

The nature and excessive amount of the rock material that is now being handled requires greater strength in all the classes and types of machinery than formerly. As a consequence a great deal of the machinery as sent down from the United States has developed weaknesses that are being corrected on all new machinery ordered.

In caring for this machinery quite an extensive shop capacity is required and owing to the widely dispersed condition of the work it was found desirable to locate, as a matter of convenience and economy, repair shops at four different points along the canal route. At Cristobal there has been constructed a shop capable of handling 10 engines at one time, one at Bas Matachin with a capacity of 22 engines; one at Empire 10 engines, and one at Pariso 6 engines. At each of the four points the French had located small repair shops, which, with the exception of the one at Empire, had been abandoned and completely hidden from view by the tropical growth. Cocoanut trees 8 in. in diameter had grown up between the machinery. This growth was cleared away and quite a large amount of old French machinery was put into operating condition and installed in the new and modern shops constructed on the old sites.

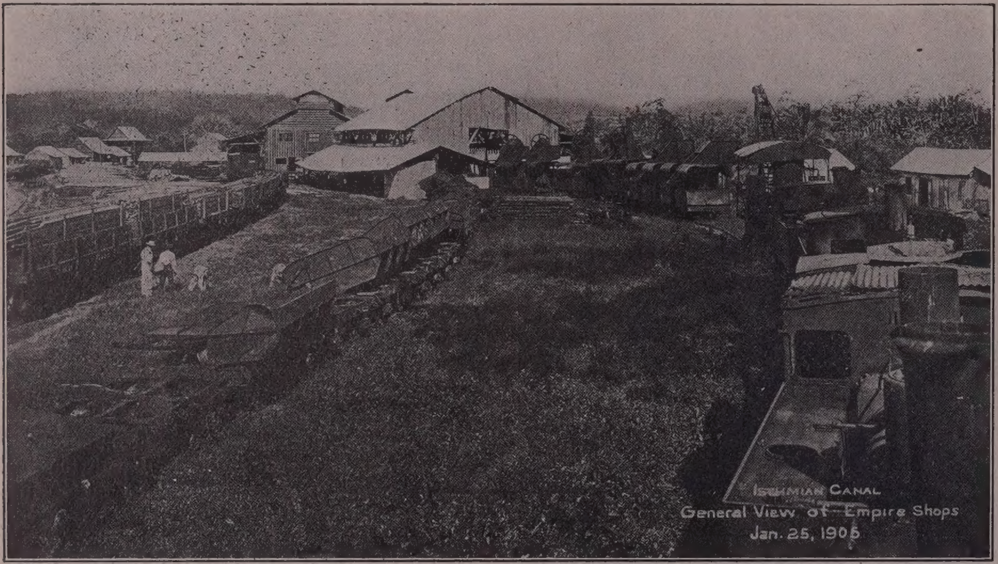
As a general rule the French machinery was found to be in excellent state of preservation. Being, however, from 20 to 25 years old, it was found to be very slow in movement and incapable of doing economical work in comparison with the latest and more modern machinery. As far as possible American machinery has been substituted in all places where the machine is to be in constant use. Except in the case of the larger machinery, retained for intermittent use, the French product has been abandoned. Where the question of economy and output constituted a small figure as compared with the interest on money invested, the machine under consideration was retained.

A great deal of the old French machinery as found on the Isthmus, though not possessing the economic features of the American machinery, has been utilized in many instances for other purposes than it was originally intended. For example, quite a large number of compound condensing engines that were intended for use in dredges, but which had never been assembled, were fitted up for shop stationary engines. The large cableway engines were found to answer favorably as hoisting engines for handling coal cars on coal shute inclines.

Large quantities of rolled sections, such as I-beams and channels, have been used in shop construction, traveling cranes, transfer tables, turntables, and other conveniences too numerous to mention. Large quantities of sheet plate varying from ¼ to ¾ in. in thickness, were found covered up with tropical growth, but in a fine state of preservation, and have been found of excellent use in building water tanks, reservoirs for air compressor plants, aprons for use between flat cars, coal chute pockets, etc.

There were also found inland a large number of Scotch boilers intended for dredges. These have been utilized for shop boiler plants furnishing steam for compressors, electric light apparatus, and other purposes. Although not as economical in the finer points as more modern boilers, they answer the purpose admirably for the period of construction required by a lock canal.

In order to furnish compressed air for the large number of 3½ and 4⅝-in. air drills at present in use on the canal, or for the other purposes to which compressed air can be applied, three large compressor plants have been arranged. These plants will have a total capacity of 30,000 cu. ft. of air per minute at 100 lb. pressure. Owing to the great distance, 12 miles, through Culebra Cut, where the air will be utilized, it was considered desirable to divide the source of supply into three units feeding into a 10-in. wrought-iron pipe extending the full length of the cut. About every 1,500 ft. along the length of the pipe are placed 10-in. valves, rendering it possible to adjust the district supplied by each compressor plant according to the nature of the work. In the event of a breakdown to one compressor plant, the remaining plants can furnish sufficient air for continuing the principal drills at work. To avoid as much as possible loss by friction in the pipes due to long-distance transmission, and still further avoid annoyances due to break-downs, a compressor unit of 2,500 cu. ft. of free air per minute was selected in preference to one of larger capacity. All possibility of delay due to break-down will be minimized as much as possible by having on hand at all times extra repair parts. It is possible that the needs of the future may necessitate the increase of compressor capacity to 60,000 to 75,000 cu. ft. of free air per minute.



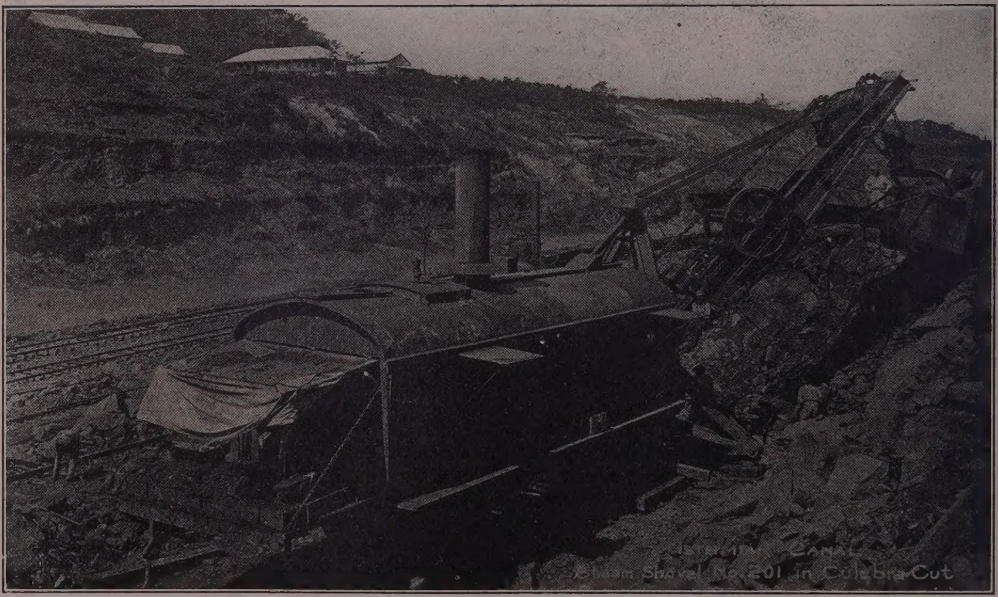
Typical Repair Shop at Empire Left by the French, After Clearing Away Vegetation.

While all machinery found on the Isthmus in the interior, at distances of 4 to 5 miles from either sea-coast, was discovered in an excellent state of preservation, except as to woodwork, such cannot be said of either the land or floating machinery found at the terminals of the canal. This plant, consisting of obsolete dredges, drop-bottom scows, tug boats, crane boats, small steam yachts and other floating material, was so badly wasted and decayed by sea air and sea water that it had sunk to the bottom. A few of the best preserved boats have been raised, repaired and temporarily utilized, but the others are as the French left them, practically heaps of scrap.

A considerable amount of trackage was left by the French in the small territory over which they were working. Numerous spurs led out into the tropical vegetation on which were stored the surplus machinery. The wooden ties had become completely decayed. Utilizing this rail, which was in a good state of preservation, was found very annoying owing to its peculiar section, 5½ in. height by 3¾ in. base. As a consequence, with the heavy American rolling stock, it was constantly turning over, necessitating the substitution of the standard American 70-lb. rail. A large amount of this has already been placed for construction work track, dump track, running track and double tracking for the Panama Railway.

Second in importance to the mechanical equipment is the question of labor. The kind and quality of mechanics it was necessary to depend upon for the first fifteen months, were exceedingly annoying, as the men had been gathered up from what had been left by the French, and also from South and Central America, speaking various languages. Within the past year, however, a very good grade, on the average, of American mechanics has been employed. As the mechanics in the United States are finding out that the sanitary conditions on the Isthmus are nothing like as represented by the majority of the current publications, and further, that such conditions are no worse, and in many instances better, than are found in our own South below the city of Memphis, Tenn., a very satisfactory class of these men have taken up their homes on the Isthmus.

The rates of pay of the various employes are as follows: Steam shovel engineers, $210 per month; steam shovel cranesman, $180; locomotive engineers (construction work), $125; drill runners, $180; trainmen, $100; conductors, $150; foremen of dumps, $125; powdermen, $100; shop foremen, $150 to $175; general foremen, $200 to $225. All monthly employes are transported from New York to Colon free of charge, and their pay commences at the hour when the vessel leaves the pier at New York. In addition all monthly employes are entitled to six weeks' leave of absence each year, with pay, together with the $20 rate to New York going and coming. They are also still further entitled to 30-day sick leave, with pay in addition, when actually sick.



American Steam Shovel in the Culebra Cut.

Skilled labor paid by the hour is rated as follows: All classes of machinists, boiler-makers, blacksmiths and moulders receive 65 cents per hour; plumbers, 75 cents; carpenters, planing mill machine hands, coach cabinet makers, 56 cents; blacksmith helpers and car inspectors and repairers, 44 cents. At the present time the working hours are eight per day. Men employed by the hour are given free transportation from New York, their time of employment commencing when vessel leaves. These are not, however, entitled to any special privileges, such as leave of absence with pay.

Living quarters are furnished to all men arriving on the Isthmus, consisting of a room with bed, mattress and pillow, but the employes are expected to furnish all linen, blankets and mosquito bar. Excellent board is furnished at the hotels of the Commission at 30 cents per meal, making boarding expenses total about $27 per month.

All hotels and quarters furnished for men are either new or old French quarters thoroughly and generally overhauled.

Desirable and competent men who are making up their minds to stay are encouraged to bring their families down. Comfortable quarters are furnished to each family. New quarters are being furnished as rapidly as the buildings can be erected. At the present time, all points where American skilled labor is located are now furnished with a good and reliable water supply and a convenient commissary run by the government. A full variety of provisions at a trifling advance over the cost of such provisions in the States can be obtained. The slight extra cost is simply to make the commissary self-supporting.

As regards a man's physical condition there is no reason why one who is free from any kidney or liver troubles would not be as safe in working on the Isthmus as almost anywhere in our own Southern States. An age limit for skilled mechanics has been established at from 21 to 45 years.

The climatic conditions, while annoying during five or six months of the year, owing to the heavy rains, are troublesome only as regards the work, by causing slides and bad track. While the atmosphere during the rainy season is very humid, this condition is due to moisture from the two oceans and is decidedly different from the humidity in our interior States. Temperature conditions vary in the shade from 80° to 87° Fahr. Under cover a breeze can always be felt, and the use of a blanket after one or two o'clock every night of the year is decidedly necessary. It can thus readily be seen that the average conditions on the Isthmus are such as would favorably appeal to even the most skeptical of American workmen.

Highway Construction.

A paper read before the American Society of Municipal Improvements by Mr. James Owen, M. Am. Soc. C. E., Consulting Engineer, Newark, N. J.

The subject of highway construction has been so extensively discussed among laymen and engineers that it would seem to be difficult to raise any question that would be novel or interesting in a gathering of this kind, save for the fact that this Association is a gathering of laymen and experts, and probably the layman would desire to gather data from the experts as his future guide in his official capacity, as to what pavement to use and what to reject, and on what basis his use or rejection should be made. The assumption of the layman that road construction is a simple mechanical proposition, easy of achievement by an ordinary untrained intellect, while commonly accepted heretofore, has been somewhat gainsaid in the last few years as the scattered attempts in this country of road improvement have been a success or a failure in the ratio that a competent engineer has or has not been in control.

The sentiment of the country at large is in favor of good roads. The engineering part in this work has hardly been in proportion to the growth of the movement, and the result has been attempts on the part of one man or another to promote his own individual ideas of the work in total disregard of the peculiar requirements of his own locality. The extent of this country is so great, the supply of road material so diverse, the climatic conditions so varying, and the practice of road building so uncrystallized that it is impossible to give hard and fast rules for road construction for any given locality. One expert in roads will tell you that drainage is the sine qua non of road construction; but when it is conceded that one-third of this continent is arid or semi-arid, the problem of drainage ceases to be a factor. Another expert will declare that Telford and MacAdam laid down the principles of road construction which cannot be properly departed from; yet if no material of MacAdam's standard can be found within 500 miles, the question of economy will put MacAdam into innocuous desuetude. Another expert has found a natural material in his section that is so applicable to the requirements of his locality that in his broad-minded philanthrophy no other material is of any account or any use.

The fact of the matter is that road construction in the United States has to be developed on its own peculiar standard, which standard will vary in every locality according to topography, climate, geological formation, density of population and the particular requirements of that population. What is a good pavement in one section for climatic reasons may be a poor pavement in another, and what may be proper in one section may be too expensive in another under similar conditions.

The fundamental factors in road construction are as follows:

The earning power of the community.

The topography and climate of the section.

The available road material at hand.

The construction of the road itself.

As to the first it can be easily seen that in a district with land worth $20 per acre the paying capacity for road construction is much less than a country worth $100 per acre, the value of the land of course being based on its earning capacity, and yet it may be a correct assumption that $20 land might be worth $100 if it had good road communication. However, in the far future, when all roads are improved, this will cease to be a factor. At present, however, the taxable value of land is potent in the cause of road construction, as it might easily be seen that a rocky farm with no possible revenue cannot be benefited by any road construction at any time. The general community must here enter and announce the plea that intercommunication by good roads is the first law of civilization. If the rocky farm cannot pay for its road, the fertile farm beyond must have its means of communication, willy nilly.

In considering the topography and climate as functions of road construction, the question of temperature first enters in, as the line of frost penetration in the ground is a vital point in construction. Methods used in road building in a warm temperature will not be found adequate for a cold climate, and coupled with this also enters the question of aridity. Where there is no water there is no frost, so the warm area can really be extended so as to include the arid area. In the frost-ridden sections, roads have to be constructed of greater depth and of harder material to ensure their stability. To offset this, however, in the extreme north the wear on the road itself is shortened by three or four months on account of snow.

Outside of the arid section drainage is paramount. This must be artificial in the flat country and properly graded in the mountain districts. That is to say, water must not be allowed to stand on a flat grade or wash out the pavement on a steep grade.

As to material to be used for roads the cost of transportation is the prime factor in the selection of material and methods of construction. Road materials must be classed under two heads, natural material to be used as found, and artificial material consisting of natural material broken up to be used. Given a natural substance of average use in an average locality, it may be considered economically preferable to an imported material of higher character, but may not give such absolute good results.

Good gravel in a well-drained country without frost, properly laid and rolled, will give ideal results if properly cared for. If used in the frost limits its period of good use in the year may be extended by putting a layer of larger stone at the bottom. In some localities there are soft limestones and gravel. The limestone makes a good foundation, but does not wear well. Use the stone for the foundation and the gravel for a wearing surface and you will find good results. If no limestone exists, then burnt clay can be made available for the foundation. If there is no gravel it would then be better to import a hard, durable stone for the wearing medium on the limestone bed.

The slates, shales and the silicates are also available for good road construction. The shales are somewhat affected by frost and require renewal, so it does not pay to import them. The silicates, however, are of different character. Take noviculate for instance. It is transported 200 to 300 miles with good economic results. Flint formations are also available, but they are rare.

Take the Mississippi Valley in general, however, and what shall be done with its roads? Good material for a wearing surface is rare and unsatisfactory, and it is probably best to lay down to the people of these communities that they must face the music and build their roads in good shape in approved methods, of selected material transported from a distance and pay their bills. Traveling through the State of Illinois for instance, what should be done? No local material and poor drainage, but plenty of rich land and rich farmers; so let them pay the bills for first-class roads.

In Alabama, for instance, with better material, not first class but available, it would be better at first to make a moderate outlay and then when the farmer gets rich, let him have the best there is. If there is gravel available let him use gravel for the present; if there is good shale let it be used, so that the present difficulty of transportation in wet weather may be eliminated.

In all these improvements, however, a trained mind should be used. It need not be an engineer's mind, but it should be an experienced intelligent intellect, so that any improvements shall have all the up-to-date requirements and no money be wasted. A first-class pavement designed to use first-class material prepared in a first-class manner will be and always has been a failure if carelessly and improperly executed, and we have all seen such cases and know the result.

In considering the construction of roads it will not be desirable to go into great detail or lay down any hard and fast rules, as I have found that excellent results can be arrived at in extreme variations of practice, and the small final difficulties can only be determined by years of experience, and this final difference may be radically upset by special natural phenomena for which no foresight can provide.

The following rules, if generally followed, always give good results:

Grades must never be level; minimum, ½ per cent.; maximum, fast travel, 4 per cent.; maximum, light load, 10 per cent.

Complete drainage.

Gravel roads; gravel with stones about the size of hickory nuts, with coarse sand and about 10 per cent. of loam.

Shale roads; about 4 in. spread, letting travel wear it down.

Gravel and limestone; limestone should be laid like a pavement and properly wedged, and the gravel put on and properly rolled.

Telford and macadam; telford from 8 to 12 in., with foundation 5 to 8 in. and broken stone 3 to 4 in. Macadam from 4 to 6 in. in two layers well rolled. Top stones well rolled with a final coat of screenings. Broken stone should be uniform in size from 1¾ to 1½ in. and properly screened, all dust taken out and put on top. Character of stone: 1, trap; 2, granite; 3, hard limestone; 4, soft limestone. In the hard traps, packing must be used for proper consolidation. In the granite and limestone the binding can be done without packing. Good rolling is necessary for proper hard road construction. Steam rollers and horse rollers are equally efficacious if consistently used.

After a road is built the question of repairs immediately enters in. A road just completed may require immediate care. Under any circumstances attention will be required within a year, and so every system of road construction that is organized, should be immediately supplemented by a maintenance organization, for in time the construction department will disappear, but the maintenance department will be permanent. At the International Engineering Congress an English engineer told me he had 400 miles of road to be maintained, but he had only built a mile and a half that year. The maintenance department is the vital point in the future of the road development of the country. If roads are built and allowed to relapse, the money is wasted, and the country retrogrades. The stimulus of good roads is marvelous. The bicycle fever was its sequence, and the automobile is now with us. The automobile is growing purely under the encouragement of good road construction and is demanding attention from engineers as to whether there should not be new means and methods for road maintenance, and I will here recite certain investigations to that end.

While the users of the present improved highways, either in carriages, wagons or automobiles, have probably not noticed a more rapid deterioration of the roadways, it has become apparent to those in charge of their construction and maintenance that more care and more money are required to keep the surface up to the proper standard. It is therefore obvious that with the probable enormous increase of travel due to the perfection of surface, either means and methods should be sought that will be more efficacious and also as economical.

Another source of trouble arising from the extended use of the highways is the dust. This is of such extent that it is not only troublesome to the traveling public, but a positive injury to abutting property, whether residential or used for farming. In fact, fruit raising near a much-used highway is almost a thing of the past. This dust nuisance has been the cause of recent investigations in Europe for means and methods for its abolition, and it will be in order to give a brief outline of experiments and results.

In congested communities, able to afford it, the past practice has been to use water by periodically sprinkling it on the surface. This has suppressed the dust, but it has the effect of rapidly rotting the roadway unless extreme care is used in the application. Of later years other material has been used, such as tar and crude oil, and in the consideration of these extraneous materials I will give a short outline of what has been done and attempted in Europe and this country.

France seems to have been the first country to consider the subject, for in 1880 the engineers at Sainte Foy la Grande used tar, but the undertaking was not a success. In Oran, Africa, in 1898, M. Cardy had some roads oiled with aloe oil and massat oil, and the results were so favorable that other towns in Algiers adopted the process. In 1898, however, extensive experiments were begun in California, and 80 miles of roads were successfully sprinkled with oil. In 1900, Engineer Rimini, of France, prepared a patent mixture of tar with a drier, the mixture being intended to hasten the drying process, but it did not give good results. In 1901, experiments were made in France with tar and oil, and since then experiments have been conducted in various localities in that country with all kinds of material, especially tar. The tar manifested such superiority over any other material that it was used exclusively in the further experiments for its practical application.

The result of the investigation of proper application of tar in France may be summarized as follows: The application must be undertaken only in dry weather. The roadway must be perfectly clean, dry and well kept. The tar will not stick if the roadway is damp but becomes loose after a short time. In cold weather the tar becomes stiff too quickly and does not spread, besides, it does not penetrate the surface of the road. If the latter is not entirely clean and free from dust the tar does not cling to it, but becomes mixed with the dust when it is spread on the road.

In the application of the tar to the surface it was found that better results were achieved if the tar was heated to a sufficient temperature to enable it to flow freely, about 210° Fahr. Many devices have been originated for properly heating and distributing the hot tar. One, used at Neuilly, consists of a hearth with a tar reservoir over it, and a smokestack to increase the draught. Two kettles are used at one time, so that the tar can be warmed in one while the other is in use. The material is poured into pots with an open spout and poured on the surface. This plant is for a moderate application.

For large stretches a large plant was designed by M. Audoin, consisting of a sprinkling barrel, which consists of a cylinder about two cubic meters capacity which rests upon a two-wheeled truck and is filled by means of a pump. The tank is warmed by a portable hearth which is pulled from under the cylinder after the proper temperature has been attained. At the rear of the tank there is, as in sprinklers, a distributing pipe with a number of holes which spread the tar for a distance of 5 ft. The contents of the tank are sufficient for covering a length of 375 ft. If smaller tanks are used, or even simple sprinkling pots with open nozzles, the tar is spread over by means of broom to ensure even distribution.

In France it has been found that before a tarred roadway is given over to traffic it is necessary to sprinkle the tar with a coating of sand. The sand further hardens the tar, protects it and prevents slipping of horses. It has been found that the sand should be scattered after the tar has been allowed to harden for two or three days. Attempts have been made, however, to coat a road with tar and sprinkle it with sand, and immediately turn the street over to traffic. Some of the sections do not seem to wear as well as the sections where the coating was given two or three days to harden. Others were quite as well in spite of immediate subjection to traffic. For spreading over the tar a rather coarse gravelly sand was used, occasionally fine sand, and here and there the street dust which had been swept together just before tarring. It is to be noted that gravel and gravelly sand gave bad results, for the larger pieces were forced into the tar coat under the action of traffic and made holes. By the use of street sweepings better results were obtained, although this is inferior to river sand. The street sweeping dust absorbs certain lighter parts of the coating The best sprinkling material is fine sand, which was used on a section in the proportion of about 1 cubic meter to 2,000 square meters of tarred road.

It is advisable to stop traffic entirely two or three days during the hardening of the tar. Where this is not feasible and would cause much inconvenience, first one-half and then the other half of the street may be tarred. The period of hardening for the tar varies between two and five days, according to the temperature, the exposure of the street to wind, the composition of the tar materials and the like. By the addition of heavy oils the period of hardening may be lessened.

The cost of the tar application in France was found to be as follows: Aug. 1, 1902, a section of road about 370 ft. long and 12 ft. wide at Champetery was tarred. It had lately been repaired with slag and gravel and was in good condition. Travel was small. From August to November, 1902, the coating wore well, no dust or mud, and the street dried well after storms. From November, 1902, to April, 1903, several traces of wear were discernible, the stones showing through. During a rainy period the tar layer rose in places and formed with the tar remnants which came out at the denuded spots in a thick sticky slime, which, after drying, served as a coating. From April to July, 1903, the tar disappeared in places, chiefly in the middle of the road.

In July, 1903, the Avenue de la Tourelle in Saint Mandé was tarred. This avenue, which has a very heavy bicycle and automobile traffic, had a limestone surface laid in May, 1903. The tarring was done in July, same year, in damp, cool weather, and the results were excellent. The tar disappeared in places where the surface was not entirely dry when it was applied. This road was retarred in June, 1904, and there was still tar in places, although not enough to prevent dust.

These and other experiments show that the tarring of the surface lasts about a year, and during that time there is no dust and little mud. It is, however, the unanimous view of the French experts that the amount of wear of the roadway is decreased through the tarring process. This can readily be appreciated since there is little dust, and hence less abrasion of the stone. The tar surface is also waterproof and prevents deterioration from penetration of the water. There is also a strong claim made as to the benefit of tar as a hygienic measure, as it has a decided antiseptic action. In England exclusive use is also made of tar for the maintenance of the surface of the roads and prevention of dust.

In this country the use of tar has become a recognized practice, although at present it is not extensive. One of the first applications was made in Jackson, Tenn., where a very successful experiment was made on practically the same lines as in France. The tar was heated to a temperature of 210°, and run over the road through a 1½-in. hose with a 1-in. nozzle. The surface of the roadway was then broomed and covered with a light coating of clean sand and screenings and rolled with a steam roller. The coating lasted about seven months. A section cut through the surface showed that the tar had penetrated one to two inches.

The town of Montclair, N. J., in 1904, coated one of its streets on a steep grade with a mixture of tar and screenings, and after a year of use this showed little results of wear. At the present time patches of the original surface are now visible, showing the wear. This year the town has covered about a mile of roads, and their surface is universally satisfactory, perfectly clean and smooth with no dust or mud. The cost of the 3,400 ft. treated this year was 30 cents per lineal foot or 17 cents per square yard. This included 300 yd. of cracked stone and screenings, and if this item be eliminated from the outlay it will be found that the cost of tarring alone would be about 5.66 cents per square yard, comparing favorably with the French result.

The authorities of the village of South Orange, N. J., are also extensively repairing the streets with tar, with good results, and the Borough of Queens, New York, has also treated miles of its roads in the same way.

There seems to be one radical difference between the French practice and that adopted here. In France they merely sprinkle the surface of the spread tar with sand, specially rejecting gravel, as they find the coarse material breaks up the surface of the hardened tar. In this country, a coating of screenings is universally spread upon the tar, with the design of incorporating as much as possible the tar with the dust.

Taking the practice in this country of using stone dust we find, of course, a large increase in cost by the extra price of the stone. On the other hand, we have the saving of wear on the road itself by the fact that the tar and dust mixture acts as a cushion and lessens abrasion.

While undoubtedly the tar application for highway maintenance seems at present to give the best results, there are other materials now in use that are demanding favorable consideration. The most prominent is crude petroleum. While this medium is undoubtedly best for an arid region, like California or Algeria, it has great disadvantages over tar in any territory where there is ample rainfall. It prevents dust efficaciously provided there are constant renewals, from three to four weeks being seemingly the limit of its usefulness. In wet weather it is objectionable, forming an emulsion with water which has a damaging effect on clothes and the paint of wagons and carriages. It also makes the surface mushy and is objectionable from that view. A sprinkling material has, however, been invented for use on roads known as westrumite. It is chiefly a mineral tar, which with the aid of ammonia or other cheap medium is dissolved in water. It is used in a 2 to 10 per cent. solution and sprinkled from tanks in the ordinary way that water is sprinkled. The surface, however, has to be clean. It can be carried on in any weather, except very heavy rain, and requires no interruption of travel. The practice is to undertake the first two sprinklings with a 10 per cent. solution at intervals of 24 hours. After that a 5 per cent. solution is used every two weeks. The cost for sprinkling with the material for three months, when sprinkling is required, would be about 3 cents per square yard, but this expense is merely for laying the dust and does not obviate the wear as in the case of tar. There is also a material intended to lay the dust known as coudrogenit, used in the same way as westrumite, but its application is limited and correct results have not as yet been arrived at.

In this country a material has been put on the market known as tarvia, which is being extensively used as the means of allaying dust, and so far its application fills the want for immediate delivery of a tar preparation for road surfacing.

Whether in the larger uses of tar in the future its market price will make it as economical as has been the case with ordinary coal tar is a fact that remains to be proved. Tar as a medium for binding stone is no recent innovation. Years ago tar pavements were in great demand and use, and some of them are in existence to-day, but the present knowledge of its use and properties is much more intimate than it was at that period.

An Unusual Concrete Retaining Wall.

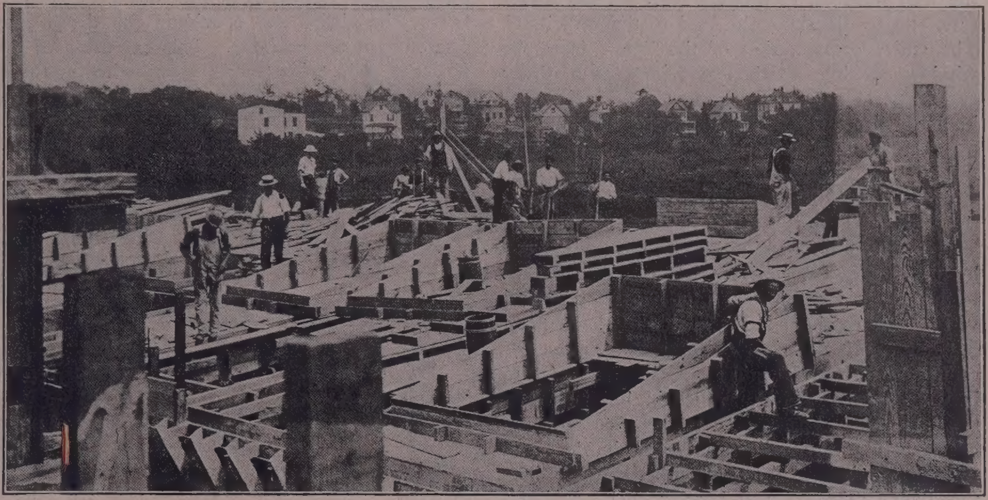
A concrete retaining wall of unusual design has been constructed on the Hirschberg-Lähn section of the Prussian railways in order to carry the track around a reservoir. It consists of a series of barrel arches with their axes making an angle of 60 deg. with a vertical line, instead of being horizontal. The maximum height of the wall is 46 ft., and its face is inclined 3 on 1. This construction enabled the weight of the embankment resting on top of the arches to be carried down to the rock forming the hillside without so much horizontal thrust as would arise with a vertical wall, and thus save the masonry, which would otherwise have been needed to resist this lateral pressure.

Reinforced Concrete Buildings for a Paper Mill.

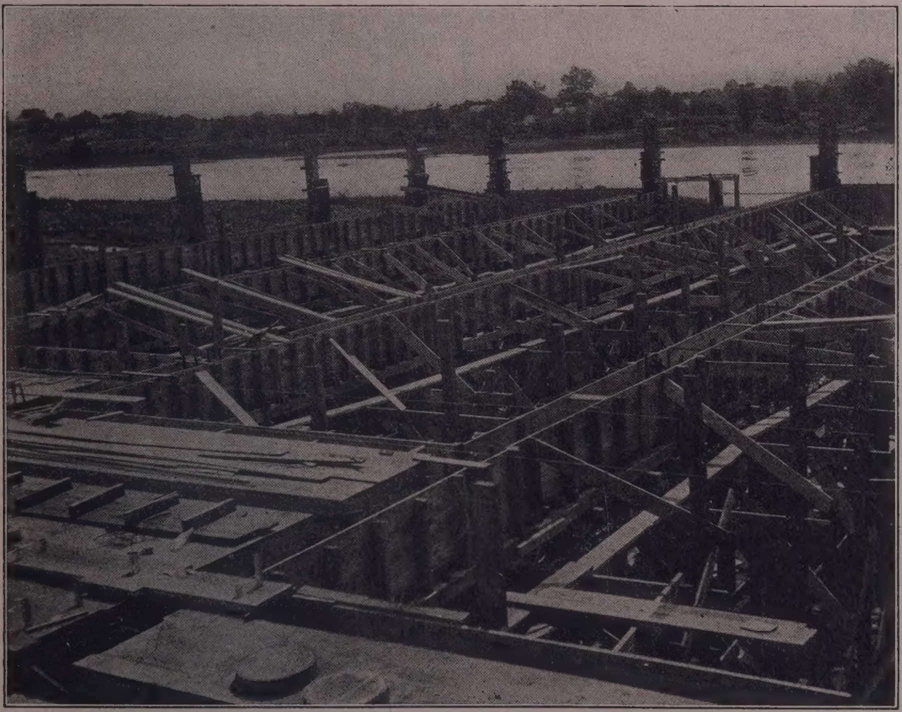
There has just been completed at Bogota, N. J., a group of large buildings for the Traders' Paper Board Co., in which reinforced concrete was adopted to secure abundant light and to provide large floor surfaces. They are proportioned for heavy floor loads and in some cases to support machinery and impact. This type of construction was selected in competition with steel, masonry, and wooden construction because it is absolutely fireproof and requires little or no expense for maintenance.

The principal buildings include an 84 x 212-ft. three-story beater house 45 ft. in height to the eaves; two 96 x 80-ft. one-story screen rooms, 18½ ft. high to the eaves, an 800 x 256-ft. one-story machine building 21 ft. high to the eaves, and several smaller buildings. The second floor in the beater house is designed for a live load of 400 lb. per square foot, including the machines installed there, and the third floor of the same building is designed for a 200-lb. live load. The roofs are all designed for a live load of 40 lb. per square foot. The first floors consist of 6 in. of concrete laid on solid earth fill. All roofs have a pitch of about 1:12 from the longitudinal center line and are supported by the exterior walls and by three longitudinal rows of columns except in the machinery building, where there is only a single center row of columns and the transverse roof girders attain a maximum span of 40 ft. The maximum span of the floor girders is 20 ft. and the columns are generally arranged 8 ft. or 16 ft. apart.

In the one-story building the side walls, as shown in the machinery building, are merely curtains of solid concrete 6 in. thick and 4 ft. high made without reinforcement. The spaces above them to a considerable height are filled with a line of windows that occupy about 70 per cent. of the total wall space. In the three-story building there are narrow belts of exterior wall just above and below the upper floor lines and the remainder of the wall space is occupied by windows with sliding sash. The wall columns have rectangular cross-sections made integral with the walls and are flush with their inner surfaces so as to form exterior buttresses.



Forms for Roof and Skylight Curbs.



Falsework and Forms for Main Girders.

The interior columns have circular cross-sections and, like the exterior ones, are made integral with the roof and floor girders and are connected to them by corbels forming solid-web kneebraces of the full width of the girders and continuous with them. Besides the crane girders and the shaft brackets, both of reinforced concrete, there are few structural features in the building except the columns, floors and roof. The details involved special design on account of the necessity of providing for a large amount of machinery in the beater house which made the construction extremely irregular, so that floorbeams and girders, panel lengths and other elements of the construction lack uniformity.

All columns have offset piers of concrete without reinforcement, carried down in open pits to footings on the hard clay at a depth of about 6 ft. below the original surface. The interior columns were all made in position, with forms of expanded metal wired together to form cylinders anchored to the piers and lined with expanded metal lath, and filled with concrete reinforced by four full-length vertical rods wired to the inside of the expanded metal at equidistant points. After the form was filled the exterior of the column was finished with a 1-in. coat of cement plaster applied with a trowel. The upper parts of the columns were made in special wooden forms connecting the expanded metal with the forms for the floor and roof girders and providing for the corbels or kneebraces which connect the columns and girders. The wall columns were also reinforced with four full-length vertical rods, one in each corner, and were made simultaneously with the walls in ordinary wooden forms.

The machine building, 80 ft. wide, is divided into two aisles by the center longitudinal row of columns which supports the roof and the runway girders of the traveling cranes, which are of 30,000-lb. capacity and 39-ft. span. These girders are integral with the columns and their corbels, and are connected in the planes of their upper surface by a continuous horizontal slab 4 in. thick and 3 ft. wide, forming part of the girder cross-section. They are reinforced by three 1-in. tension bars in the bottom of each girder and by one ½-in. bar in the upper outside corner of each girder. Cast-iron chairs are bedded in the concrete and bolted to it to receive the girder rails.

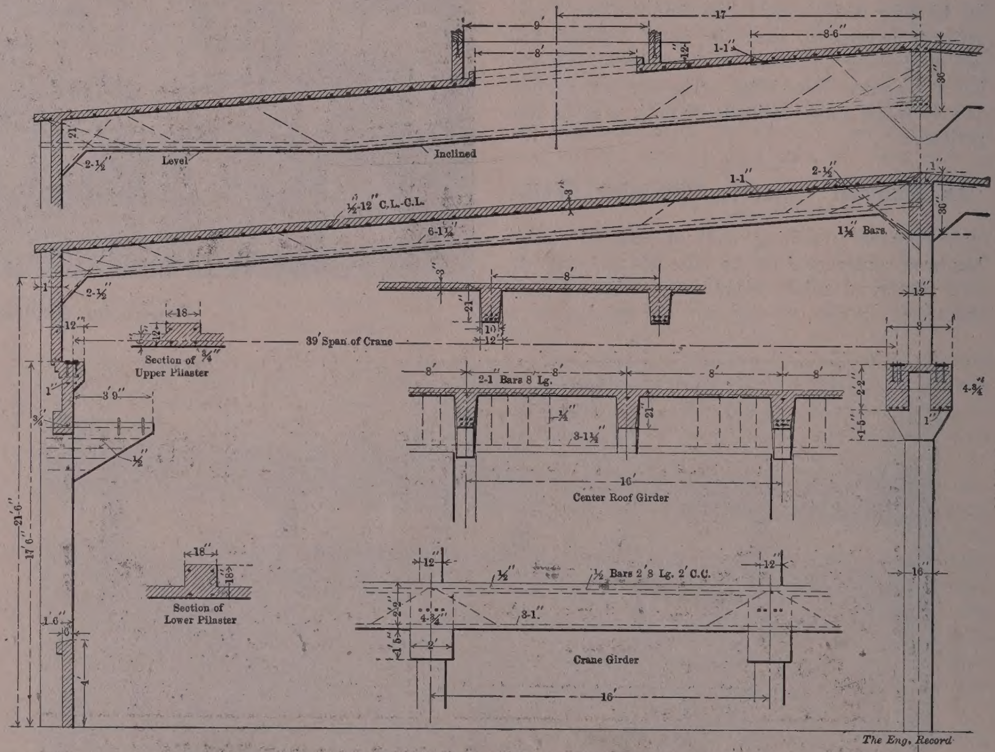
The corresponding wall girders for the same cranes are of irregular outline and practically consist simply of offsets on the interior face of the wall sufficient to provide seats for the girder rails and to distribute the load to the wall itself. The entire cross-section of the latter, from the window openings to the eaves, acts as a girder about 9 ft. deep. It is reinforced by a pair of 1-in. bars directly under the rail, by a ¾-in. bar over the windows and by another one between the rail and roof girders. Concrete brackets 45 in. wide project from the lower columns just below the runway girders to carry lines of shafting. They are uniformly 10 in. thick and are reinforced by two sets of five horizontal ½-in bars that extend through the thickness of the column in two vertical planes about 2½ in. inside of the center.

The tops of the center columns 16 ft. apart are connected by a ridge girder 36 in. deep and 12 in. wide, reinforced by three 1¼-in. bottom flange tension rods. These girders support at their center points intermediate rafters 21 in. deep and 10 in. in minimum thickness, with six 1¼-in. bottom flange reinforcement bars in each. Like all other beams and girders, their total depth includes the thickness of the floor or roof slab, which in this case is 3 in. and is calculated to act as a part of the girder for short distances beyond the latter. The sides of all girders are slightly tapered to facilitate the removal of the forms and in this case are 12 in. apart at the top and 10 in. at the bottom, giving a batter of about 1:18 on each side. Shear is provided for by short reinforcement rods in the kneebraces or corbel brackets and by bending the ends of the bottom flange bars upwards. The bars are made of different lengths and are arranged so that successive bars terminate at different distances from the center of the girder and provide inclined web members at several points determined by the shear diagram, as shown in the elevation of the girder. The roof slab is in this case supported entirely by the rafters without longitudinal joists or purlins and is reinforced with a single tier of ½-in. longitudinal rods 12 in. apart on centers.

After the design for the building had been accepted, it was determined to make a large skylight in the roof, thus cutting out a considerable area of the roof slab which has been calculated to act in compression with the rafters. In order to strengthen the latter to compensate with this change, several of them were made deeper, as indicated in the detail elevation. This change increased their dimensions so much that they exceeded the permissible clearance at the lower end of the rafter. Therefore at this point the bottom edge of the rafter was made level at the clearance line and was continued to intersect the inclined surface of that portion of the rafter having the increased depth. This arrangement allowed the necessary clearance at the expense of regularity in construction and accounts for the rather peculiar and unsymmetrical appearance of the girders.

In the screen room, the general construction corresponds with that in the machine building, except that there are three lines of longitudinal columns dividing the building into four aisles and the dimensions of the columns and girders vary with the loading. There are runways for five-ton girder cranes of 39-ft. span in the two center aisles. Those supported by the center columns are like those in the machine building, but those carried by the side columns are of special construction conforming to their eccentric connections with the square columns. They are normally 12 in. wide and 26 in. deep above the tops of the corbels and are reinforced with four 1-in. bottom flange bars.

In one place two intermediate columns are omitted, necessitating a runway girder span of 24 ft., which also carries the shaft brackets and receives from them a considerable twisting stress. Provision for this is made by making the regular section of the girder integral with an unsymmetrical lower section of the full depth, 4 ft., of the bracket, thus affording a total depth of about 7 ft. for the girder and providing full depth connections for the brackets. This extension of the girder is 18 in. wide to correspond with the thickness of the column and the top and bottom flanges are 14 in. deep. The peculiarity of construction consists in locating the 6-in. web eccentrically, so that its face is in the plane of the column face and intersects with the brackets there. This gives an unsymmetrical disposition of material in the flanges and allows three of the six 1¼-in. steel tension bars to be placed at the greatest distance from the neutral axis so as to resist most effectively the twisting stress from the bracket.



Semi-Transverse Section Through Machinery Building.

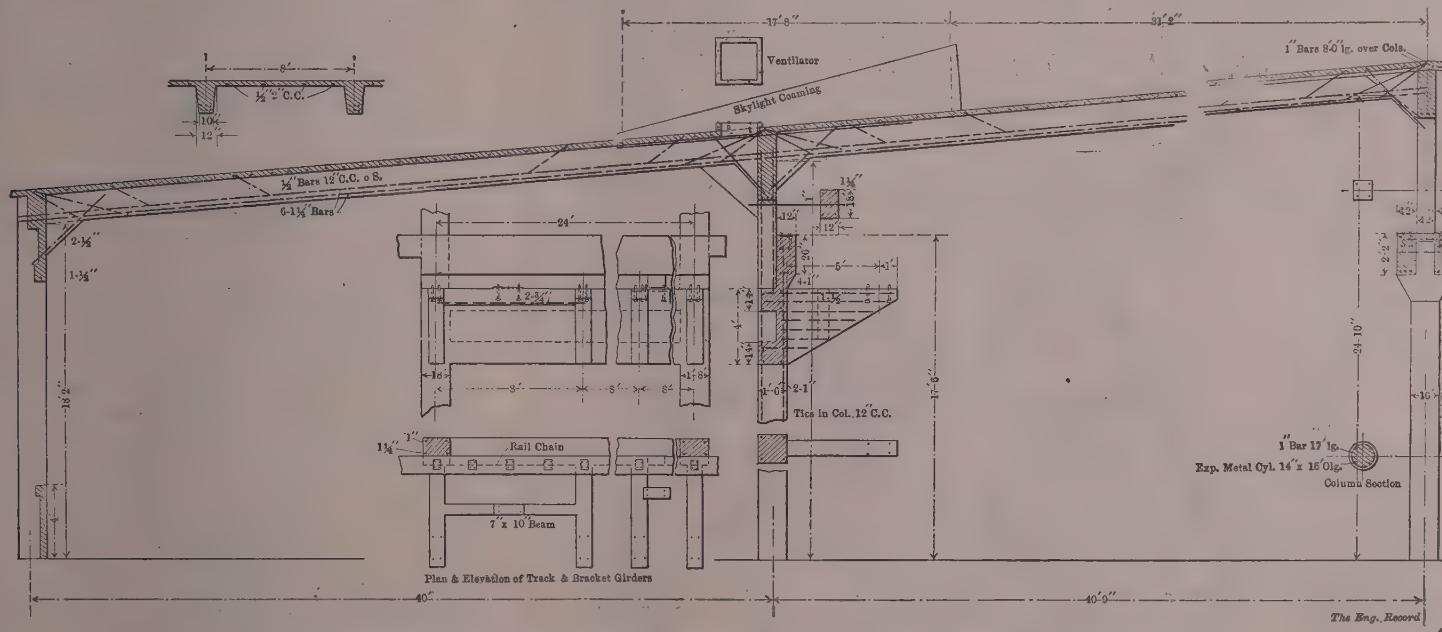
The 61 x 136-ft. one-story boiler house is unsymmetrically arranged with a single row of longitudinal columns 30 ft. high and 36 ft. on centers from the rear wall so as to provide room for the boilers on that side of the building while the narrower aisle on the other side serves for a passageway in front of the boiler doors and contains a full-length coal bin about 10 ft. wide, with its long walls connected by 1-in. tie rods from 4 to 5 ft. apart vertically. The walls of this bin are continued above the main roof of the building to enclose a gallery in which there is a small coal bin filled by a conveyer plant and discharging through bottom valves into automatic cars running over the roof of the building. The contents of the main bin are discharged through gates near the bottom and the space below these gates is permanently filled with coal, which serves as an emergency reserve and can be shoveled out if necessary. As the clearance between the coal bin and the boiler front is not sufficient to permit the removal of the boiler tubes, a 3 x 5-ft. rectangular horizontal reinforced concrete chamber is carried through the coal bin on the center line of each boiler front and is provided with doors at both ends which can be opened to permit handling the tubes when necessary. thus affording an unobstructed passage through the coal bin.

In the main building numerous piers are located on the lower floor to provide foundations for the machinery. These are essentially concrete walls and piers, generally made without reinforcement. They are arranged to clear a 7½ x 40-ft. cistern 10 ft. deep, with side walls 8 in. thick, reinforced by ½-in.. vertical bars 6 in. apart on centers and ½-in. horizontal bars 2 ft. apart on centers The bottom is similarly reinforced with bars in both directions. The interior of the cistern is waterproofed by a 1-in. coat of 1:1 cement mortar and the top is covered by a floor slab 5 in. thick with transverse ½-in. reinforcement bars 8 in. apart.

Adjacent to the cistern an L-shaped concrete drain crosses through the center of the building and along one end. It is a rectangular open conduit 5 ft. wide and 4 ft. deep outside and 3 ft. wide and 34 in. deep inside, with rounded corners. It is made without reinforcement and the top is covered with movable reinforced concrete slabs 3 in. thick and 44 in. wide. This drain receives the waste water from the buildings and the rainwater from the roof. The latter flows from the ridge both ways to the eaves where it is intersected by vertical concrete flash boards about 6 in. in height which form a sort of parapet on the inclined roof surface just above the eaves. The parapet is divided into lengths corresponding to two panels of rafters. In the middle of each panel there is a leader close to the eaves line. The parapet extends from this leader to a point about a foot nearer the center of the roof in the middle of each adjacent panel, where it intersects the corresponding parapet from the next leader, thus forming a zigzag line along the edge of the roof that diverts the water both ways to the leader and gives a pitch providing complete drainage of the roof without giving any further longitudinal inclination to the gutter than is furnished by the regular transverse pitch.

All concrete was made 1:2½:5 with Portland cement furnished by the Pennsylvania Cement Co., and screened broken stone from ¾ to 1 in. in diameter. All reinforcement is made with Johnson corrugated bars proportioned for unit stress of 16,000 lb. Concrete is figured to carry a compressive stress of 600 lb. Broken stone and sand were delivered on railroad cars and shoveled into elevated bins alongside the track, the materials afterwards being shoveled out as required for construction. Concrete was mixed in three Ransome machines located about equidistantly on the principal buildings, and from them was delivered by wheelbarrows to the elevators, raised to the required height, wheeled over the forms and dumped as required.

Owing to the great irregularity previously mention in the size and location of the beams and girders, it was impossible to make the forms in duplicate and they were built as required without the use of interchangeable or knockdown panels. The side pieces of the girder forms were connected to the bottom piers with triangular filler blocks in the angles to chamfer the corners of the girders in all cases. Above these blocks they were tied together with double twisted wires 4 ft. apart on centers which served to support the reinforcement bars. When the molds were stripped, the projecting ends of the wires were cut off, leaving the interior portion permanently imbedded.



Transverse Section Through Screen Room, Traders' Board & Paper Company's Plant.

The column forms were filled from the top with concrete wheeled over the falsework and floor molds. Concrete was mixed very wet and care was taken to flush the mortar to the top in the floor slabs, which were finished with checkered rollers.

Work was commenced in November, 1905, and has just been completed, the process being considerably impeded by the irregularity of construction and the necessity of conforming to changing plans for the machinery. The Curtin-Ruggles Co., of New York City, designed and supervised the work.

To Overcome Quicksand Troubles on a portion of the tunnel which the New York, New Haven & Hartford R. R. is building at Providence, R. I., it is proposed to use an inverted arch 2 ft. thick for the floor of the tunnel and to carry heavy concrete walls down through the quicksand outside the tunnel section. The space between the quicksand and the concrete invert will be filled with gravel. By this system of construction the quicksand is completely confined and is expected to cause no trouble when the tunnel is placed in operation.

The New Central Station of the Birmingham Electrical Department.

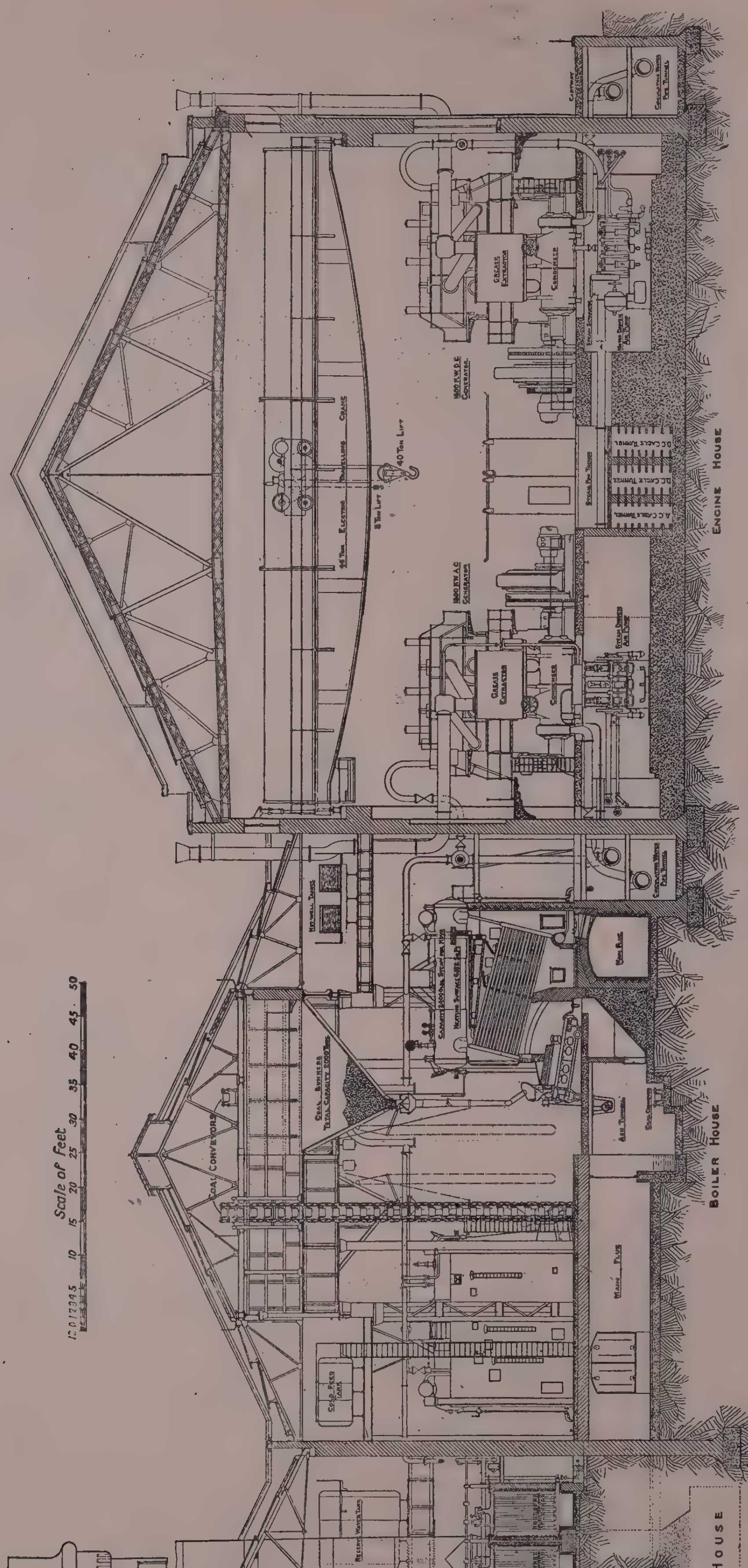
The new central station of the Electrical Department of Birmingham, England, which was officially opened early this month, is an example of British design to meet four requirements for current: 1, a 220 and 440-volt direct-current supply for lighting and power purposes in the vicinity of the station; 2, a 440-volt direct-current supply to two other stations to help them meet the demands for lighting and power; 3, a 550-volt direct-current supply to the electric railways within two miles of the station; 4, a 5,000-volt three-phase supply to substations in outlying districts. The station was designed by Mr. R. A. Chattock, city electrical engineer of Birmingham, who built it large enough to hold direct-current equipment of 13,000 kw. capacity and alternating-current equipment of 13,500 kw., although the machines now installed for these two kinds of current are rated at but 7,000 and 4,500 kw., respectively.

The building is located alongside the Birmingham and Fazeley canal and comprises a 275 x 100-ft. engine room, a 275 x 89-ft. boiler house and a 275 x 47-ft. economizer room. The accompanying cross-section, which, like these notes, is taken from "The Engineer" of London, gives a good idea of the general arrangement of the apparatus. The switch galleries, shops and battery room are located on the street front, while a centrifugal pump house is located on an arm coming in from the canal. The first equipment consists of six Belliss engines, each having an output of from 2,140 to 2,680 b.-h.-p., three Belliss engines of 1,000 i.-h.-p. each, and each coupled to a 500-625-kw. alternator, and two turbo-generators of 500-kw. each. The six larger engines, four of which are to drive direct-current dynamos, and two to drive alternators, have cylinders of 25 in., 36½ in. and 55 in. diameter, and a stroke of 33 in.

Steam is supplied by Babcock & Wilcox boilers, at a pressure of 180 lb. on the square inch. There are ten of these boilers. Each has 6,182 sq. ft. of heating surface and contains 280 tubes, arranged in twenty sections, each section having fourteen tubes 18 ft. in length. Each boiler is provided with one of the firm's superheaters, designed to impart 150° superheat to the steam and containing 898 sq. ft. of heating surface, made up by 88 solid drawn tubes 1½ in. in diameter, bent into U-shape, and connected at both ends to wrought steel boxes of manifolds. Each boiler is also fitted with the firm's double mechanical chain-grate stoker, each double stoker consisting of two 5 x 10 ft. stokers, thus giving a grate area of 100 sq. ft. per boiler. The speed of these grates can be varied from 6 to 27 ft. per hour. Each boiler is estimated to evaporate 24,000 lb. of water per hour with ¾-in. natural draught and with coal of at least 10,000 B.t.u. calorific value. There are four feed pumps, each rated at 9,600 gal. per hour. But one economizer has been installed, but there is room for three more. It has four groups of 320 tubes each. Large water storage tanks have been placed in the economizer room to contain a supply of cold water from the town mains, and hot water from the air-pump hot well discharge.

All the six larger engines are stated to be strictly duplicates of one another in every particular. The only difference is that those driving the alternators are run rather faster than the others. Thus the direct-current engines revolve at the rate of 160 r.p.m., and the alternating-current engines at a speed of 166⅔ r.p.m. At this speed the periodicity of the current generated is exactly 25 per second. The piston speeds in the two cases are 880 ft. and 917 ft. per minute, respectively. The engines are designed to run condensing, but arrangements have been made whereby the exhaust may be made to atmosphere through Belliss & Morcom automatic valves. Piston valves are fitted to all the cylinders, the high-pressure valves being of the variable expansion type, operated from the governor through special relay gear by which the cut-off can be adjusted. The engines are all provided with heavy flywheels, and the energy calculated to be stored up in the revolving parts is 3,400 and 4,600 foot-tons for the direct and alternating current units, respectively. The engines are lubricated by a forced system which supplies oil to all the bearings under a pressure of 20 to 30 lb. from duplicate oil pumps worked from the high-pressure valve eccentric. Emergency stop valves, workable from either the engine-room floor or the platform above, are provided.

Each engine has its own surface condenser beside it. The cooling water is obtained from the canal, there being an independent pumping installation for this purpose. It contains two 20-in. steam-driven centrifugal pumps and one 12-in. motor-driven pump of the same type. The exhaust steam before entering the condenser is passed through a Baker grease extractor. There are 1,767 ¾-in. brass tubes, representing an aggre-



Cross-Section of the New Central Station of the City of Birmingham.

gate length of four miles of tubing in each condenser, and having a cooling surface of 4,200 sq. ft. The air pumps are on the Edwards principle, and are 18-in. diameter and have a 12-in. stroke. They run normally at 80 r.p.m., but can, if necessary, be speeded up to 120 r.p.m., so as to enable each set of pumps to serve two main condensers. The air pumps are alternately steam and motor driven, the two methods of driving being thus equally divided throughout the engine house.

The three smaller engines are triple-expansion, and generally follow the same lines as the larger engines. The cylinders are 17 in., 24 in. and 37½ in. in diameter, and the stroke is 18 in. They run at 250 r.p.m., and each, as already mentioned, drives an alternator. These three engines exhaust into a common surface condenser, which is a duplicate of those for the larger engines.

Two exciters have been installed. Each is of 100-kw. capacity, and is of the Belliss two-crank type, running at a speed of 450 r.p.m. Each of these engines drives a 100-kw. direct-current generator, built by the General Electric Co.

In addition to the foregoing generating machinery, two 500-kw. steam turbo-generators, built by C. H. Parsons & Co., have been installed. These turbines, together with two exciter engines, are coupled to a surface condenser and motor-driven air pumps.

The four 1,500-kw. direct-current generators were supplied by Dick, Kerr & Co. and have an overload capacity of 25 per cent. The two 1,500-kw. and three 500-kw. alternating-current machines are of the British Westinghouse type and also have 25 per cent. overload capacity. Two Phoenix 100-kw. balancer sets and two 25-kw. Phoenix boosters have been provided, and there is a 200-kw. Phoenix motor-generator to furnish railway current off the direct-current lighting buses during light load at night.

The bunkers over the boiler house have a capacity of 2,000 tons of coal, and are fed by a conveying gear which also handles the ashes. The coal will ordinarily be delivered in barges, which will lie alongside a 24-in. Robins belt conveyor running down the side of the arm of the canal on which the station is located. This conveyor is driven by a 6-h.-p. electric motor and can handle 60 tons of coal an hour while running at a speed of 200 ft. per minute; in other words, three barges can be unloaded simultaneously on it. About 50 ft. from the delivery end of the conveyor, the belt is inclined upward at an angle of about 20 deg. and discharges into a small hopper. The coal then passes through an automatic weighing machine to hopper at ground level.

From this hopper the coal is taken through chutes to the filling apparatus of two bucket conveyors, each 960 ft. long and driven by a 16-h.-p. electric motor. Provision is made for installing a third later on for the purpose of feeding and drawing from an auxiliary coal storage of 3,000 tons capacity to be built on the waterfront. Each conveyor is rated at 60 tons an hour at a speed of 45 ft. per minute.

On their return trip through the basement, the conveyors pass in front of the boiler ash-pits and the ashes are shoveled into them. On reaching the canal end of the boiler house, they again rise vertically to the level of an enclosed bridge and pass horizontally over it. On the underside of this bridge are two ash bunkers, each holding 60 tons. One of these is over a driveway and the other over the arm of the canal, so that the ashes may be loaded into either carts or barges.

Concrete Sewers are now being used in Pittsburg and vicinity. One now under construction in the city proper is 5 ft. in diameter and is built in place, while one in Crafton, a suburb, consists of lengths of reinforced concrete pipes from 27 to 60 in. in diameter. These lengths are molded by the side of the trench and lowered into it.

Mechanical Equipment of the Carnegie Library Extension, Pittsburg, Pa.---II.

Ventilation.—Owing to the free public use of the Carnegie Library Extension, mechanical ventilation has been provided in all parts and the apparatus, having been designed for conditions of maximum occupancy, is an equipment of great magnitude. In fact, it is one of the largest installations of ventilating fans ever placed in a single building, having an aggregate capacity of over 600,000 cu. ft. of fresh air per minute, and similar capacity for exhaust ventilation. To avoid excessively large units and properly sectionalize the equipment, the fresh-air apparatus has been arranged in fifteen stations, having nineteen fans, and the exhaust equipment in twenty-one stations with 30 fans.

The ventilation is independent of the heating throughout the building, the fresh air supply systems being designed to deliver air tempered only to the normal temperatures of the rooms supplied. The heating is accomplished by direct radiation throughout, as described last week. In only one instance is this arrangement departed from, namely, in the music hall, where it was thought desirable to provide in the fresh-air supply system, sufficient radiation to permit indirect heating if it should be convenient. In the music hall section the building arrangement is such that there is little exterior wall exposure requiring heating to counteract the cooling effect, this division being almost entirely surrounded by other sections of the building, and the purpose of this indirect heating equipment is rather for quickly raising the temperature in the hall prior to occupancy than for general heating. In another instance, also, a smoking-room underneath the foyer has been equipped for indirect heating by a reheater stack in the fresh-air delivery duct supplying that room; this arrangement is due to limitations of space in the smoking-room, by which radiators were prohibited. An incidental advantage of this independence of the heating and ventilating systems is that while the fresh-air supply systems are not intended for indirect heating, the tempering coils in all of them are of sufficient capacity to provide satisfactory heating of the building in moderate weather, in case of possible derangement of the direct radiation system.

Fresh Air Supply.—Fresh air is supplied to the building by nineteen centrifugal blowers, arranged for convenience in making duct connections in three general divisions. One division includes systems 1 to 6 in the northeast corner of the basement under the museum; the second comprises systems 7, 8 and 10 underneath the lecture hall, and the third division embraces systems 9, 11, 12 and 13 underneath the library division. Even with this distribution of the various equipments, the connections in some cases were not all that might be desired, a number of ducts from the first division to the northwest corner of the building being over 500 ft. in length; in general, however, a convenient workable installation was secured. In two cases isolated fan systems were necessary, one system 14 in the attic to supply the reading-room, and the other system 15 in building A, a small extension of the museum at the southeast corner, to provide for alcoholic specimens, which, owing to fire risk, it was thought desirable to isolate from the remainder of the building. The arrangement of these systems and the enormous systems of duct work is illustrated in the accompanying basement plan.

The group of fans for systems 1 to 6 occupies a 50 x 130-ft. space in the northeast corner of the basement, where nine large outer windows provide for the air intake. The entire outer portion of the room, 14 ft. in width, is devoted to one large continuous air filter through which all the fans have a common intake. Immediately within the filter enclosure are the seven fans in a continuous row, with their intakes from the filter chamber containing tempering coils. Five of these systems have single fans, driven by direct motors, and one system has two fans, driven in tandem by its motor. All six have three-quarter housed steel-plate fans with discharge outlets under the floor in all cases, thus providing ample headroom unobstructed by overhead duct work.

The second group for systems 7, 8 and 10 occupies the greater portion of an 80-ft. square room in the basement in the south end of the building. In the outer circular portion of this room is the filter chamber, having two large windows for the cold air inlets, and a large air filter of the usual staggered-frame cheesecloth type. Owing to a less convenient arrangement of the fans in this room, intake connections of considerable length were necessary, two of which are galvanized-iron ducts carried above the floor and the other an underground flue. Similarly, two of these systems have overhead galvanized-iron delivery ducts, while the third has an underground connection to a riser flue in a nearby wall.

Details of Equipment of Fans for the Ventilation of the Carnegie Library Extension.

Station.	Section served.	Fans, No.	Fans, type.	Fan wheels, diam.	Fan wheels, width.	R.P.M.	Cu. ft. per min., supply.	Cu. ft. per min., exhaust.	Motor, h.-p.	Tempering coils, sections.	Tempering coils, ft. of 1-in. pipe.
1.	First floor and basement......	1	Cent.	7 ft.	4 ft.	185	32000	.....	15	6-2 row	3,234 lin. ft.
		1	Cent.	7	4	204	.....	35000	20		
2.	Foyer	1	Cent.	9	4½	160	50000	.....	25	6-2 row	6,500 lin. ft.
		1	Cent.	7	4	204	.....	35000	20		
3.	Architectural & sculpture halls	2	Cent.	8	4	130	54000	.....	15	7-2 row	10,000 lin. ft.
		1	Disc.	6	...	300	.....	35,000	10		
4.	All art galleries.............	1	Cent.	9	4½	183	57000	.....	35	6-2 row	7,710 lin. ft.
		1	Disc.	5	..	275	.....	21000	5		
		1	Disc.	4	..	400	.....	15000	4		
		1	Disc.	6	..	300	.....	35000	10		
5.	Engine room..................	1	Cent.	7	4	204	35000	.....	20		
		1	Cent.	8	4	180	.....	39000	24		
6.	Museum (constant)	1	Cent.	9	4½	144	45000	.....	20	6-2 row	5,640 lin. ft.
		1	Disc.	5	..	250	.....	18000	5		
		1	Disc.	6	..	300	.....	35000	10		
7.	Museum (occasional)	2	Cent.	8	4	163	70000	.....	30	7-2 row	10,000 lin. ft.
		1	Disc.	4	..	350	.....	13000	4		
		3	Disc.	5	..	275	.....	21000	5		
		1	Disc.	6	..	250	.....	28000	7		
8.	Lecture hall	1	Cent.	7	4	167	28000	.....	20	6-2 row	3,936 lin. ft.
		1	Cent.	7	4	167	.....	28000			
9.	Book stack room	1	Cent.	10	5	130	57000	.....	40	Tempering	4,284 lin. ft.
		1	Cent.	9	4½	130	.....	40000		Reheating	6,426 lin. ft.
10.	Kitchen	1	Cent.	4½	2⅓	289	11000	.....	12	6-2 row	1,284 lin. ft.
		1	Cent.	5	2⅔	289	.....	15000			
11.	Library—south wing	1	Cent.	10	5	120	52000	.....	18	7-2 row	9,005 lin. ft.
		1	Disc.	7	..	275	.....	52000	12		
12.	Library—west wing	2	Cent.	6	3½	200	44000	.....	15	6-2 row	6,504 lin. ft.
		1	Disc.	4	..	400	.....	15000	4		
		1	Disc.	6	..	225	.....	25000	7		
13.	Music hall	2	Cent.	8	4	150	64000	.....	20	6-2 row	8,394 lin. ft.
		1	Cent.	9	4½	160	.....	50000	30		
		1	Disc.	4	..	350	.....	13000	4		
14.	Reading room	1	Cent.	6	3½	170	20000	.....	10	6-2 row	3,045 lin. ft.
		1	Cent.	6	3½	170	.....	20000			
15.	"Building A"................	1	Cent.	3	1½	400	4500	.....	4	6-2 row	1,080 lin. ft.
		1	Cent.	3	1½	400	.....	4500			
16.	Toilets, front of bldg........	1	Disc.	3½	..	400	.....	11500	4		
17.	Toilets, left center	1	Disc.	3	..	400	.....	7000	2		
18.	Toilets, service	1	Disc.	4	..	350	.....	13000	4		
19.	Toilets, library	1	Disc.	4	..	425	.....	17000	5		
20.	Toilets, library, upper floors..	1	Disc.	2½	..	500	.....	5000	2		
21.	Toilets, music hall	1	Disc.	4	..	350	.....	13000	4		
	Total=49 (28 centrifugal and 21 disc.).						623500	659000	501		87,042 lin. ft.

The third group of fans, for systems 9, 11, 12 and 13, is located underneath the library section of the building. Equipment 9 is in the basement of the wing connecting the old section of the library with the new book stack section, which it supplies, while the remaining three are underneath the old section of the building. This latter room is 32 x 86 ft. in size and has several window openings into interior court 3 for the fresh-air supply. The fans are arranged in a row in the center of the space adjacent to a long filter rack at the outer side of the room, similar in arrangement to that of the first group. This filter chamber is 12 ft. wide and continuous throughout the length of the room, and from it the fans have intakes through short direct ducts containing tempering coils. The delivery connections are through overhead ducts in systems 11 and 12, while those of systems 9 and 13 are underground. System 9, supplying the book-stack section of the building, is fitted with an air-wash equipment to cleanse the air before delivery to the book storage. For this reason the cheesecloth air filters are replaced by an air-wash spray chamber, eliminator and necessary tempering and reheating coils.

Air Cleansing.—The air filters are all of the usual cheesecloth type with frames mounted in zig-zaged racks to secure the maximum area of filtering surface.. The large filter for the first division of fans has 164 frames and a total filtering area of 5,412 sq. ft. The filter for systems 7, 8 and 10 has 80 frames and a total net filtering area of 2,400 sq. ft. The filter for systems 11, 12 and 13 has 97 frames and a total net filtering area of 4,655 sq. ft. The isolated equipments of systems 14 and 15 have filters of 450 and 175 sq. ft. respectively. The areas of these filters are proportioned for velocities of 30 to 45 ft. per minute, with the exception of the large filter for the first group, which, owing to its size and the improbability of all its fans being operated to full capacity at the same time, is designed for a maximum filtering velocity of 50 ft. per minute.

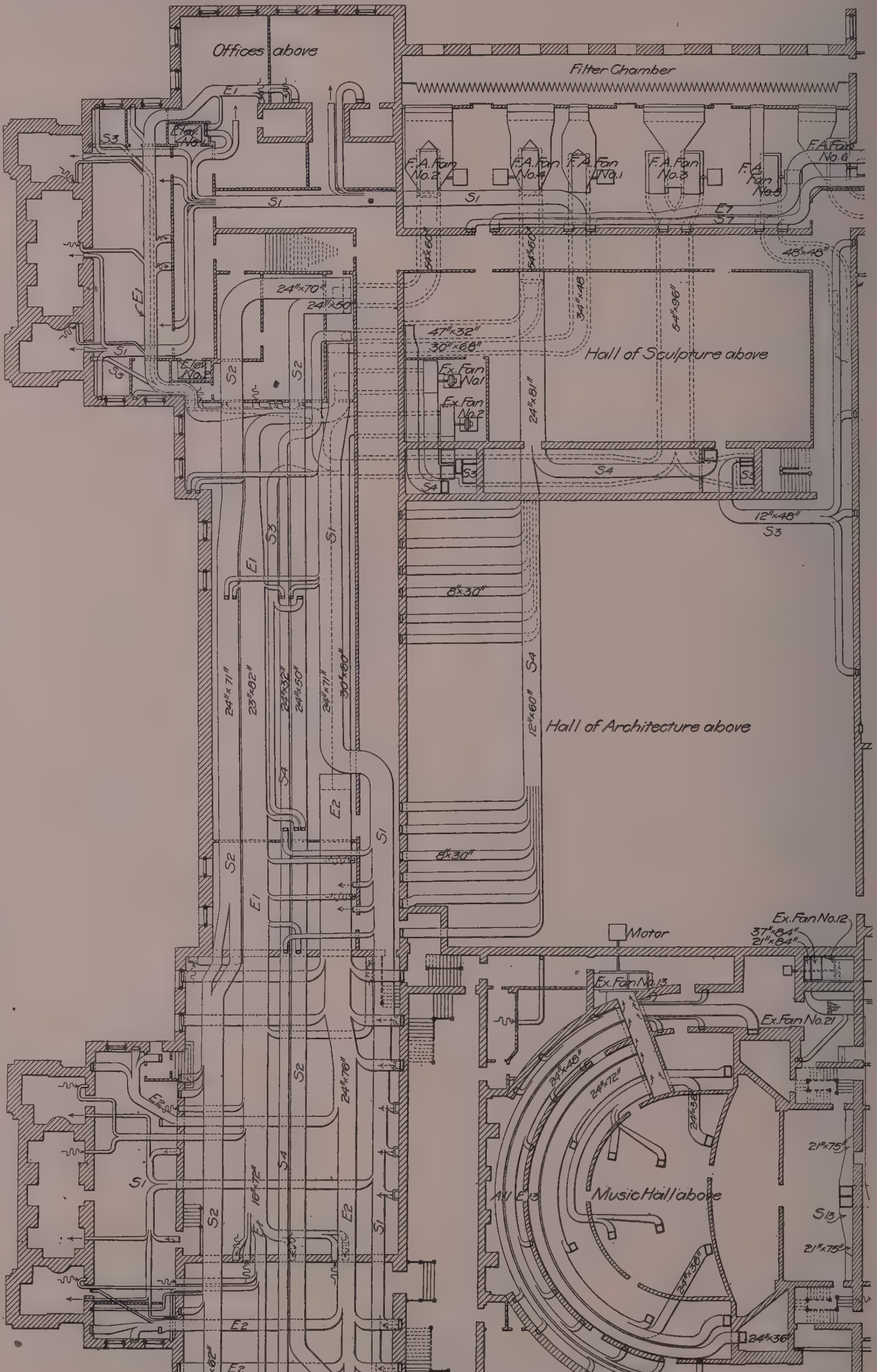
The filters have substantial wooden frames with exterior dimensions of 3 x 11 ft. and are covered with copper wire netting to support the cheesecloth. The frames are supported by galvanized steel framework fitted tightly to the floor and ceiling, and fixed in place by fastenings which enable them to be readily replaced, a large number of extra frames being provided for use while cleaning those which have been in service. A novel feature of the chamber arrangement is the use of rolling shutters for cutting off the intake supply to any fan in case it is out of commission temporarily. The intake openings in the filter chamber partition are fitted with Wilson rolling shutters which close tightly and prevent recirculation from the fan chamber back into the filter room.

The air-wash equipment for system 9 was considered preferable to the usual type of filter for air to be delivered to rooms in which books are stored. It was thought that in this way dust could be most effectively kept out and at the same time the humidity maintained more nearly uniform, two important factors in the preservation of books. The equipment consists of a spray chamber, an eliminator for separation of entrained particles of water from the air, and the two sets of tempering coils, one to raise the temperature of the entering air above freezing point in very cold weather and the other for tempering the air delivery to the desired temperature. The spray chamber contains nozzles spaced close together in staggered rows in order to deliver a continuous sheet of spray at right angles to the line of flow of the air, the result of which is that all the air is brought into intimate contact with the spray and thoroughly cleansed. The nozzles are of the side outlet type, but have attachments by which they may be opened for a direct stream to clear out any possible obstructions; the levers operating these nozzle openings are operated by handles outside of the casing. The spray chamber casing has a cross-sectional area of 100 sq. ft., so that at the full capacity of this system, the velocity of the air through the spray is not over 10 ft. per second.

The eliminator, located between the spray chamber and the fan intake separates any particles of water which may be carried along mechanically by the passing air. It consists of a number of rows of inclined baffle plates, made up of vertical strips of sheet copper 6 in. wide, with hook edges on the sides toward the fan to engage the particles of water coming in contact with the strips. The eliminator has a free flow area slightly less than that of the spray chamber, to cause an increased velocity of flow during the separating action. The base of the eliminator chamber is inclined toward a drip pan below it to which drainage from the baffles flows readily. The water for the nozzles is used over and over continuously until it becomes dirty. It is circulated by a small motor-driven centrifugal pump having a capacity of 470 gal. per minute, which has an intake through a series of coarse and fine screens and a 5-in. suction, and delivers to the nozzles through a 4-in. line. The motor is of 5-h.-p. capacity and runs at 500 r.p.m. This air-washing equipment was installed by Thomas & Smith, Chicago, Ill.

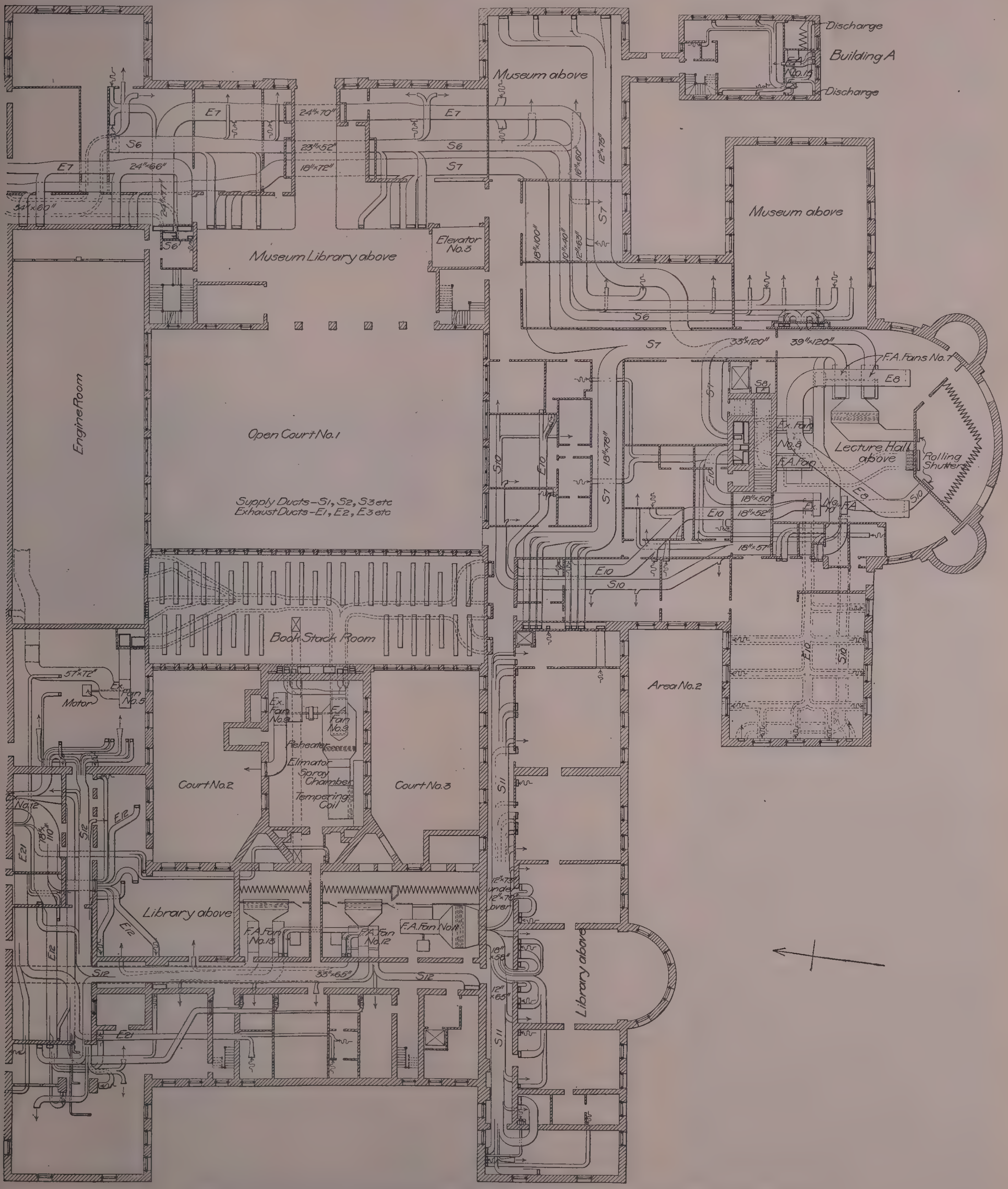
Fans and Coils.—The supply fans are all of the Sturtevant steel-plate centrifugal type of the dimensions and capacities indicated in the accompanying table, and the greater part have three-quarter housings with steel bottom pans. Their casings are No. 10 B W. G. gauge steel plate heavily braced and have carefully balanced blast wheels with curved floats of No. 12 steel plate mounted on cast-iron spiders. They are in all cases driven by C. & C. slow-speed multipolar motors, operated from 220-volt power circuits. The motors are direct-connected to the fans through flexible couplings and are fitted for a speed range of from two-thirds to full speed through field control. They are controlled through combined starters and speed control rheostats, operated by a single lever, but no resistance is used except for starting purposes. These controllers are all fitted with no-voltage release and overload circuit breakers.

Heating coils have been fitted to all but one of the supply systems for tempering the fresh air in cold weather. The system supplying the engine room is not thus equipped as, owing to the heat given off by the steam-using machinery, cold fresh air only is needed for ventilation. Each of the other systems has a tempering coil only, except No. 9 which, owing to the use of the air-washing equipment, has both a tempering and a reheating coil; there are thus a total of 15 coils, which have a total heating surface of 87,042 lin. ft. of 1-in. pipe. The distribution of heating surface in each system is indicated in the accompanying table of apparatus. The coils are for the greater part made up of six and seven two-row sections each of the Sturtevant mitre pattern. They are 1-in. pipe screwed on 2½-in. centers into separate corrugated cast-iron headers on steam and return ends. The coils are encased in jackets of No. 10 steel plate with connections to the filters and fan intakes of similar weight.



Northerly Portion of the Basement Plan.

Tempering Control.—The tempering coils of the fresh air systems are, like the direct radiation of the heating system, under automatic thermostatic control, for which the Johnson system is used. Each of the fifteen heaters is controlled in two groups of sections, one embracing the two outside sections and the other the remaining four or five. The outside sections are controlled by a thermostat in the filter chamber or cold air intake, and the larger group by a thermostat in the delivery duct. These thermostats have different settings, that in the main delivery duct being adjusted to operate the larger group of sections as the temperature of the air passing through the duct rises above or drops below 73° or whatever temperature the thermostat is set for, depending largely on the length of duct and resultant heat losses therein; the supply of these sections is, therefore, continually being opened or closed in order to maintain the temperature of the fresh air delivered as nearly constant as possible. The thermostat in the cold air chamber is set for 38° Fahr., and admits steam to the two outside sections only when the outside temperature drops below this point which would cause objectionable cool drafts from the supply registers, whenever the larger groups were cut out temporarily. The various sections of each heater are also independently fitted with hand valves so that closer regulation is possible by manual control. The regulation apparatus is operated pneumatically, and the equipment for it was mentioned last week.



Southerly Portion of Basement Showing Arrangement of Ventilating Equipment.

Ducts.—The connections from the fans to the sections of the building are, in eight of the systems, made through brick ducts underneath the floor, jointing at distant points the riser ducts or ceiling flues of galvanized iron, while the remaining seven fan systems deliver to the supply branches through ceiling ducts of galvanized iron, their arrangement being shown in the accompanying drawings of the basement. These basement ducts are in general proportioned for comparatively high velocities, the average being about 1,200 ft. per minute. In the vertical flues, the velocities are reduced one-half or even more, ranging from 500 to 600 ft. per minute. In some of the ducts many bends and changes of direction were necessary and some of them extend to inconvenient distances, a few as far as 500 ft., but in general a very satisfactory arrangement has been secured. All curves have been planned to permit an easy flow, the inside radius in every bend being greater than the width of the duct. A feature of the work in the basement is that the ducts have been run in general below the steam piping systems by which the disadvantages of passing pipes through them are avoided. All branch ducts have dampers with quadrants outside indicating their position and are fitted with adjustable deflectors to obtain the proper distribution of the flow. The galvanized-iron ducts are of particularly substantial construction, all having one dimension of 48 in. or over, being made of No. 18 gauge iron, braced with angle iron; ducts 30 in. size and over are built of No. 20 gauge, those 12 in. and over of No. 22 gauge, while all smaller ducts are of No. 24 gauge.

For temperature records, all of the five filter chambers and the main tempered air ducts of the fresh air systems have accurate thermometers with indicating dials. The fourteen thermometers inserted in air supply ducts have long stems projecting 12 in. into the ducts. All thermometers have 6-in. dials with scales graduated, for the tempered air ducts, from 20° to 180° Fahr., while for the cold air chambers, they are graduated—from 10° to 120° Fahr. System 9, which is fitted with the air-washing equipment, has a thermometer in the cold air intake as well as in the supply duct connection, by means of which the temperature adjustments may be made in the tempering and reheating coils of that system for proper control of the humidity.

All duct work in the basement connected with the fresh-air supply systems have coverings of magnesia blocks 1 in. thick, wired on and finished with an outer protecting covering of 10 oz. canvas. The tempering coils, fan casings and connections between them, as well as the centrifugal exhaust fan casings, are similarly protected by magnesia blocks 1½ in. thick, wired in place, cemented and encased in jackets of 10 oz. canvas. All tempered air flues at points above the basement, whether in walls, suspended ceilings, or attic spaces, are covered with 1-in. magnesia blocks similarly wired on and encased in 10 oz. canvas jackets. The tempered air riser flues carried in outside walls are insulated by air cell covering, ½ in. thick, held in place by galvanized iron angle pieces on each corner and copper wire fastenings. Additional insulation in the basement is provided above the ceilings of the cold-air filter chambers by 2-in. magnesia blocks supported on wire lath suspended from the ceiling beams by 1-in. T-irons; this finish is subsequently covered with hard-finished plaster to prevent leakage of cold air into the building. All of this insulation covering is 85 per cent. magnesia asbestos and was installed by the Valleau-Costigan Co.

Delivery connections for the supply of fresh air to the rooms are in practically all cases planned for downward supply, the registers being located in the upper portions of the rooms or in the ceilings, while all exhaust ventilation registers are in or near the floor. The fan of station 1 is intended solely to supply air to the front portion of the basement and a section of the first floor near the front entrance. The duct connection is extended from it underground for a considerable distance beyond the corridor, where a 14 x 48-in. branch leads off to supply the northeast corner of the basement and auxiliary rooms at the northeast entrance; in the front portion of the basement it rises to ceiling ducts which similarly supply the northwest corner of the basement and portions of the northeast entrance. System 2, of somewhat larger capacity, supplies air to the foyer on the main floor, a column room 60 x 140 ft. in size at the northwest corner, through which entrance is had to the music hall; this room is especially intended for social functions during art exhibitions and the like, and provision has been made for an ample supply of air when it is heavily crowded. The duct work for this system is similarly carried in the basement, with numerous branch connections to the risers supplying the ceiling delivery outlets. System 3 supplies the architectural hall and hall of sculpture, system 4 supplies the art galleries, and system 6 is intended for a constant supply to the museum reading room, a room facing court 1, in all of which cases comparatively short simple connections were possible from the fan deliveries to the ceiling registers. System 5 is devoted wholly to the supply of cold fresh air to the engine room, and the details of its connections will be referred to in a subsequent article.

The duct work for fans 7, 8 and 10 is carried entirely upon the ceiling, with the exception of system 8, from which a short underground connection is made from the fan to a flue in a riser shaft nearby. System 7 has an extensive system of distribution duct work, being intended for the occasional supply of air to the different portions of the museum whenever increased occupany may warrant it. Ceiling duct distribution systems are also used for fans 11, 12 and 13, while for fan 9 underground flues distribute the air to wall risers at either end of the book stack room. Systems 11 and 12 are both used for different sections of the library, while system 13 supplies the music hall. Further details of the ventilation connections to certain portions of the building and the exhaust systems will be described in an article to be published next week.

This ventilating equipment was designed, together with the heating equipment described in the preceding article, by Baker, Smith & Co., New York, and installed by their Pittsburg branch. The architects of the building were Alden & Harlow, Pittsburg, Pa.

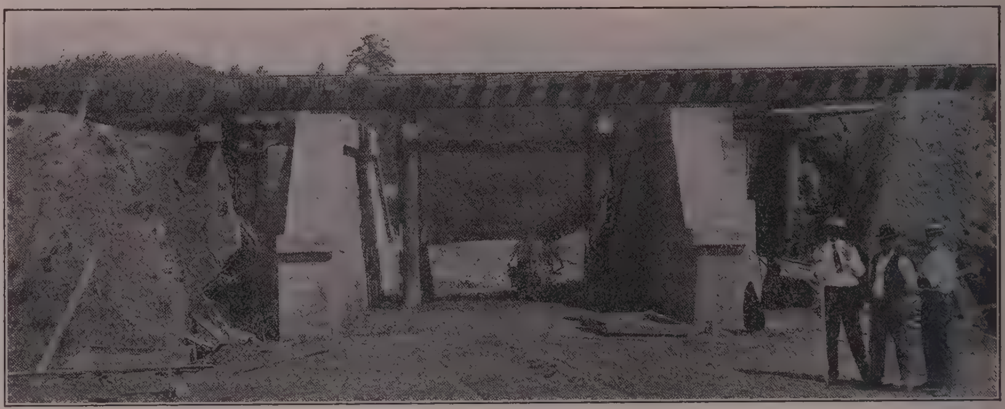
(To be continued.)

A Draft-Recording Gauge shown at the recent engineering and machinery exhibition at London consists of a float, shaped like a miniature diving bell, resting in a quantity of glycerine contained in a cylindrical pot. The cover of this pot contains a small hole, through which the normal atmospheric pressure acts on the surface of the glycerine outside the float. The chamber inside the float is connected by a pipe with the boiler side of the damper in the uptake of the boiler plant, and there will thus be the same pressure within the float that there is in the uptake. The vertical motion of the float is indicated by a needle on a dial or by a pen passing over the surface of a strip of paper on a drum driven by clockwork. This instrument was exhibited by Messrs. Sanders, Rehders & Co., of London, who also showed a steam load meter. This consists of a disk of metal inserted at one of the joints of the steam main and perforated by a hole somewhat smaller than the diameter of the main. This disk has a couple of holes running in from its edge nearly to the orifice, where one of them terminates in a small opening on one side of the plate, and the other in a similar opening on the other face. Pipes lead from the holes to a pair of water columns, which are connected in turn with a mercury gauge. The apparatus depends for its action upon the principle that for each position of the mercury column there can be but one velocity of flow through the orifice in the disk.

Depressing a Highway Crossing.

The improvements now in progress for the New York Central & Hudson River R. R. include the abolition of many grade crossings. In some cases the highways are elevated over the tracks, and in other cases they are depressed. A typical example of the latter is illustrated in the crossing of Bloomfield Road at Ionia, N. Y., where a single track is carried over the highway on a plate-girder span about 25 ft. long. The method of construction was very simple and involved the driving of four bents of piles which were capped and received track stringers laid in trenches dug in the roadbed during intervals between trains. The ties and rails were replaced on the stringers, and being thus supported enabled an excavation to be made underneath the track for the depressed grade of the highway as well as for the abutments of the new span. The latter were carried down to wide footings, forms erected and the concrete abutments built in them in the usual manner.

The accompanying engraving shows the abutments after the forms had been stripped from the concrete, and it was ready to receive the superstructure. The track is carried on both sides of the abutments by the trestles and stringers already mentioned. The plate-girder span was placed with a steam crane on the substructure. The space between the abutments and the solid bank was back-filled, leaving one trestle bent permanently imbedded in it at each end of the span.



Method of Supporting Track while Building Depressed Roadway.

A Test for B. Coli has been introduced by Mr. G. R. Spalding, superintendent of the New Milford filters of the Hackensack Water Co., to obtain exact quantitative results as quickly as possible. He uses for the purpose a circular glass plate illustrated in the "Technology Quarterly." It is 7⅜ in. in diameter, with a ¼-in. rim rising ½ in. above its top face, which has 64 small indentations, each ¼ in. deep and ⅝ in. square. In using the plate a lactose broth five times the usual strength is prepared and tubed. One c. c. of this broth and 1 c. c. of the river water are added to 9 c. c. of sterile water, 1 c. c. of litmus is added and the mixture poured into the plate. Violent shaking of the plate sidewise is necessary to distribute the solution evenly among the cavities. With filtered water, 5 c. c. of the sample are diluted with 5 c. c. sterile water and 1 c. c. each of broth and litmus added. If the plates are prepared late in the afternoon they show the formation of acid the next morning. Any cavities with such indications are reinoculated into fermentation tubes, which are ready for examination for gas the following morning. The number of cavities showing acid formation is an indication of the degree of purification, but only a small percentage of these cavities subsequently gives typical gas formation.

The Engineer as a Citizen.

Address by President Alexander C. Humphreys of Stevens Institute, at the dedication of the New Engineering Building of the University of Pennsylvania.

It is peculiarly appropriate that the University of Pennsylvania should develop a thoroughly efficient department of engineering education in view of the important scientific work done by the many-sided Franklin, upon whose suggestion the original Philadelphia Academy was organized. In view of what I have in mind to say to-day, I am particularly struck by the following words which appear in the original charter granted to the Academy in 1753 by Thomas and Richard Penn:

"The well-being of a society depends on the education of their youth, as well as, in great measure, the eternal welfare of every individual, by impressing on their tender minds principles of morality and religion, instructing them in the several duties they owe to the society in which they live, and one towards another, giving them the knowledge of languages, and other parts of useful learning necessary thereto, in order to render them serviceable in the several public stations to which they may be called."

It is interesting to note that the charter of 1755, creating the college, enlarged the scope of work to include "Not only the learned languages, but the liberal arts and sciences."

Since Franklin's day, tremendous strides have been made in the sciences, and especially of late years in that branch in which he did pioneer work—electricity. It is to the credit of this university that it has recognized its responsibility in connection with this advance, and has quietly progressed in the line of engineering education until to-day we are assembled to recognize formally the addition to its educational plant of a complete engineering building, probably second to none of its kind and equipped to give adequate instruction in several branches of engineering. Should not this magnificent growth from so small a beginning strengthen our faith and be an encouragement to all of us who are struggling to meet our responsibilities along similar lines?

There is passing over the United States to-day a wave of reform—some of it real and honest—much if it not so. To-day reform is popular and to a certain point I am willing, yes, anxious, to go with the popular party. Reform is needed, much needed, in the United States and in many directions. And reform always has been needed and always will be needed in this world of ours. Here is where the first mistake is made by the reformers. Their proposition seems to be that the conditions now attracting their attention are singular.

The people at large have been deceived as to our condition in connection with the need of reform as compared with times past. Many men of standing hold the opinion and are willing to act on the belief that the present condition as to the wrongful use of the money power is such that relief can be found only through a revolutionary upheaval. If the case is so desperate that a surgical operation is required, let us hope that our Republic will not be in the position of the unfortunate patient who dies under the knife, although the surgeon declares the operation to have been successful. And what has been the chief agency in this deception? Unquestionably yellow journalism.

Yellow journalism of the ordinary sensational type is an old story in America. Dickens shows us—perhaps the picture, caricature-like, is an exaggeration, but caricature-like, it contains the elements of truth—that yellow journalism had a footing with us in the days of Martin Chuzzlewit and Mark Tapley. Comparatively, this type is harmless. But the extreme yellow journalism of to-day is something very different. We now have to face a systematic effort to deceive the people by a partial telling of the truth, and an extended telling of untruth, with the deliberate intention of stirring up discontent and antagonism between classes.

Public opinion in connection with our form of government is a necessary safeguard of liberty. But to be a safeguard, it must be sane public opinion, and not public clamor instigated by a section of the press which is influential in spite of being conscienceless. There are too many to-day who are willing to push aside their individual responsibility in this connection by relying or pretending to rely upon the good sense of the so-called plain people. But these yellow journals are sedulously and constantly engaged in the effort to corrupt this good sense.

Others tell us that our Republic is safe in the hands of our young men. These are urged to take part in political movements and especially in movements looking to the betterment of civic conditions. Undoubtedly, if rightly employed, here is a powerful agency for good. But these young men must not be encouraged to believe that they are capable of helping the cause of good government simply because of their youth. As a rule, inexperience and immaturity go with youth. If in our public affairs we need the fire and enthusiasm of youth, as we do, we also need thorough knowledge of facts, followed by their judicial application. Real reform must be based upon a careful, competent, honest consideration of all obtainable evidence and data.

To-day, all over the land, we find indiscriminate abuse of corporations. What is fair and honest is condemned along with that which is unfair and dangerous to our national life. If we condemn indiscriminately and thus unjustly, so surely will there be a reaction, and public opinion, seeing that injustice has been done, will be carried to the other extreme and again become indifferent to real evils. And the last condition shall be worse than the first. If wrong has been done under the mantle of trusts and corporations —and unquestionably such is the case—that is no reason that we should believe that corporations as such are necessarily evil in their work and influence. It is a commentary on the sincerity of some of the most blatant of yellow journalists that, while condemning corporations as a whole, they avail themselves of the protection to be found in corporate organization to secure immunity from personal responsibility. And are we not forced to acknowledge, much as we may regret the necessity, that the yellow journals have been given their opportunity all too often through the hasty, intemperate, non-judicial utterances of those occupying the highest positions within the gift of the people? Are these men, occupying their high positions through the votes of the people who have trusted them, to be absolved from responsibility because they plead, or the plea is entered for them, that they are sincere in their beliefs, are personally honest in their acts and have effected reforms in spite of their indiscretions? They cannot so escape their final responsibility. It used to be thought that responsibility thrust upon an office holder would steady him and make him a safer guide than his public utterances before election had seemed to warrant.

The effect of the present tendency to destructive criticism is to kill or at least discourage individual enterprise. National enterprise can result only from individual enterprise; and the latter necessarily is held in check and finally killed if the individuals come to believe that the Government will not permit them to reap fairly where they have sown. Much, perhaps, nearly all, of the present unrest comes from lack of information and from misinformation as to the conduct of certain of our industries. The evils which flow from general lack of information are systematically cultivated by misinformation supplied by the worst of the yellow journals.

Then to-day the problem is—how shall we correct the false impressions created by those who systematically aim to deceive and by those who, while honest in intention, are not deterred from rash statements by their ignorance and inexperience? First we should be firm not to believe evil of any one or anything on the unsupported statements of the yellow press. Beyond that the remedy must come from the dissemination of the truth. The nation as a whole needs the honest services of those who know.

But, it may be asked, why this discussion in connection with the dedication of a building to be devoted to engineering education? I will try to show in a few words that this discussion is appropriate to the occasion.

In this country the varied and bountiful gifts of nature have, in no small degree, been utilized for the common good through the efforts of the workers in pure and applied science. This country's present commanding position in the industrial field is, in considerable measure, due to the efficient preparatory work done by our engineering schools. And incidentally let me say, while all classes have, directly or indirectly, profited by the industrial prosperity of the nation, it is to be deplored that those who have acquired great wealth from industrial undertakings have as a class failed to show in a practical way their appreciation of their obligations to these institutions.

To whom should the public look for the facts concerning industrial undertakings? Certainly to those who are engaged in the work, who understand the underlying principles involved; who, knowing all the details and appreciating that part truth often serves to deceive, are honest enough to tell the truth, the whole truth and nothing but the truth.

During the last decade the management of our industries has been falling more and more into the hands of the men who have received a preliminary training in our engineering colleges. If this is to continue, it must be the graduates of our technical colleges to whom we must look more and more for protection from the evils to which I have referred. Questions are continually arising which can be settled only through expert advice. The people must come to have confidence in those who give these expert opinions. Unfortunately, the title "expert" has been too often degraded by those who have assumed to speak as such. Too often our experts accept retainers to tell part only of the truth, and possibly to cloud over, distort or deliberately hide other parts of the truth. Such expert advice brings discredit upon our profession and affords an opportunity which the enemy is not slow to seize.

Again, the so-called expert often errs through ignorance. It must come to be recognized within our own ranks that the fields of science and practice have so widened of late years that no man can honestly claim to be able to cover authoritatively more than a limited area of either of these fields.

There are a number of fairly well defined branches of engineering, such as civil, mechanical, mining, naval, electrical and chemical. But no one man can hope even to cover authoritatively every portion of any one of these branches. To be thoroughly efficient, the engineer must closely specialize within his profession. And yet we find public opinion on intricate and complex industrial questions based upon the dictum of men who have at the best but a general knowledge of the matters involved. Especially it is to be regretted that graduates of engineering colleges, possibly competent in some one branch of the great field of engineering, presume to instruct in connection with some other branch on which their knowledge is only of a general character.

Education is a boon. It is well for a nation that its youth should be educated, as was argued by your Benjamin Franklin and his associates. But a little knowledge is a dangerous thing and much knowledge may be even more dangerous if not built on the foundation of character.

The engineer, to be an engineer in anything more than title, must be practical. His work must be based upon correct and complete theory, but it must be first and last practical. Can the engineer—that is, the civil engineer as distinguished from the military engineer—be practical, can he economically apply the truths of nature for the benefit and convenience of mankind; in other words, can he really be an engineer, unless he is competent to practice his profession within the necessary commercial limitations and in accordance with standard business methods? Can he disregard the question of return on investment? These questions, if fairly put, answer themselves. But still there are engineers who seem to believe that engineering is something which can be practiced without regard to money values and that others can be trusted to coordinate the engineering and commercial elements of the enterprises in which they are concerned. These men may be ingenious mathematicians, they may even be eminent as scientists, but they are not engineers. The man who is willing to spend a dollar scientifically to save fifty cents cannot be classed as an engineer, nor can he be of much assistance in meeting the present yellow journal danger. The man to so serve the cause of truth must be fully qualified to practice his profession in conformity with the limitations of commercial and industrial practice; to the knowledge and training gained in in the school of engineering he must have added that knowledge and training which is to be gained only in the exacting school of experience.

Then the question is raised—what should the college education include that is not now generally covered in the regular four years' course? First it must be acknowledge that the courses are crowded to the point where nothing more can be safely added unless there is a corresponding elimination. Through the steady and rapid advance in engineering science we are constantly having thrust upon our attention new matter for introduction into our courses. But where this new material cannot advantageously be substituted as illustrations and applications of scientific truths in place of other material obsolete through displacement, the new must necessarily be refused admission. We must encourage ourselves in the reflection that our engineering courses are, after all, preliminary, and to a certain extent, elementary, and that it must in any case remain for each student after graduation to learn thoroughly all the details of some one—possibly narrow—branch of engineering or industrial operation. While every engineer-student should, after four years, have a good general knowledge of engineering science and practice and be thus prepared to acquire rapidly and surely a specific and certain control of some one branch of the profession, we must recognize that we cannot graduate our men as fully equipped engineers, ready to assume positions of responsibility in any part of the engineering field. And are not the employers often at fault, even some of those who themselves are graduates in engineering, in expecting the young graduate to be able at once to do work which probably the employer himself was not qualified to do for years after his graduation? Is not too much expected of the modern education? There is no royal road to learning; there never will be, and no progress in educational methods will ever relieve the students from the hard work required for mental discipline and specific training. Should we not constantly bear in mind that the amount of work required in the four years should be limited to the capacity for thorough work by the 80 per cent. students?

How, then, with the four years already crowded, are we to find time to give our students some preparatory training in the branches required to enable them to take up their work in conformity with commercial requirements? First let us see if we can agree with Huxley that "The great end of life is not knowledge, but action. What men need is as much knowledge as they can assimilate and organize into a basis for action; give them more and it may be injurious." Is it not probable that in certain directions we are giving our students more than they are yet prepared to assimilate and organize as a basis for action? Should they not be subjected to a well-balanced course? Should they not then at least be taught the necessity for practicing in conformity with commercial limitations and methods?

I contend that every engineer-student should have some instruction in the principles of accounting, in depreciation, business law, patent law, banking, specification, and even of sociology. And in connection with the business side of their training they should be made to see the importance of the correct use of language. They should be given opportunities to see how the work of the world is impeded and hindered through the ambiguous expression of thought. They should be taught that it is not enough to know, but that they must be able to give effect to their knowledge through the use of correct, clear, explicit and forcible language. More particularly in this business department they should be warned by those who can speak from experience of the pitfalls into which they are liable to fall and especially through the efforts that probably will be made to purchase their professional opinions if these opinions prove to be of value. Here, as in no other department, can the ethics of the profession be impressed upon the young engineer-student. As religious instruction is excluded from engineering courses, it is all the more incumbent upon us to show our students the lines along which they should practice if they wish to maintain their self-respect.

Some authorities oppose the broadening of our schemes of instruction on the score that necessarily the effect must be to make them less specific and more superficial. Others oppose making the courses more technically specific on the score that necessarily the effect must be to narrow them. I venture to maintain that the change I recommend would broaden the instruction and also make it more thorough and more specifically adapted to the needs of the engineer-student. To reach this result the selection of matter for elimination must be made with the utmost care, keeping constantly in view the work for which the engineer-student is being specifically trained, and that we are not only giving him knowledge, but we are training him to think straight, and that it will remain for him to acquire in the school of experience that additional training in application which cannot be obtained elsewhere.

In this university you are already equipped as few educational institutions are to supplement as I have suggested the studies more directly concerned in the technical side of engineering. I refer to the Wharton School of Finance and Commerce.

Even if only one hour a week during the Junior and Senior years could be devoted to these economic subjects, the students would be better prepared to go out into the industrial world to promptly equip themselves to take authoritative positions—positions from which they could do much to counteract the danger arising from the indiscriminate condemnation by yellow journals of the results obtained from the combination of capital and individual enterprise working under corporate organization. Even if, with the time saved by elimination of studies of less comparative value, we could only give our students before their graduation a keen appreciation of their need of the class of knowledge I have referred to, the time would be well spent.

This is an industrial nation, and the people should, therefore, have the opportunities to learn the truth as to the fundamentals of industrial management, and the lawmakers should have the opportunities to learn the special conditions, local and otherwise, affecting each branch of industry. This information must come from those who, knowing the truth, are willing to place it before the public. The public must first have confidence in the ability and integrity of their informants, and here it becomes the duty of our technical colleges to train their students to take the positions in the world of industry which will qualify them in their several stations to fully serve their country as fountains of truth.

In conclusion, let me quote a passage from an address by that ardent champion of truth, Thomas Huxley, delivered in 1880, upon a somewhat similar occasion to the present; namely, the opening of the Technical College in Leeds.

. . . "It is not beside the mark to remind you that the prosperity of industry depends not merely upon the improvement of manufacturing processes, not merely upon the ennobling of the individual character, but upon the third condition, namely, a clear understanding of the conditions of social life on the part of both the capitalist and the operative, and their agreement upon common principles of social action. They must learn that social phenomena are as much the expression of natural laws as any others; that no social arrangements can be permanent unless they harmonize with the requirements of social statics and dynamics; and that, in the nature of things, there is an arbiter whose decisions execute themselves.

"But this knowledge is only to be obtained by the application of the methods of investigation adopted in physical researches to the investigation of the phenomena of society. Hence, I confess, I should like to see one addition made to the excellent scheme of education propounded for the college, in the shape of provision for teaching Sociology. For though we are all agreed that party politics are to have no place in the instruction of the college; yet in this country, practically governed as it is now by universal suffrage, every man who does his duty must exercise political functions. And, if the evils which are inseparable from the good of political liberty are to be checked, if the perpetual oscillation of nations between anarchy and despotism is to be replaced by the steady march of self-restraining freedom, it will be because men will gradually bring themselves to deal with political, as they now deal with scientific, questions; to be as ashamed of undue haste and partisan prejudice in the one case as in the other; and to believe that the machinery of society is at least as delicate as that of the spinning-jenny, and as little likely to be improved by the meddling of those who have not taken the trouble to master the principles of its action."

THE EFFECT OF CANAL COMPETITION in fixing rates was well shown in a statement submitted to the U. S. Circuit Court in a recent trial regarding rebates given by the New York Central line. A large wholesale grocer found that he could ship sugar from New York to Michigan points cheaper by water via the Erie Canal than by an all-rail route, and this plan was frustrated only by giving a 70 per cent. rebate from schedule charges to the sugar making company.

Some Experiments on the Permeability of Cement Mortars to Water Under Pressure.

By Joseph W. Ellms, Chemist, Commissioners of Water Works, Cincinnati.

About five years ago the writer undertook a series of experiments on the permeabilty of cement mortars to water under varying pressures, which gave results so much in accord with more recent observations by other investigators made along these same lines that a description of the work, together with the data obtained, may be of interest. Exepriments were made upon both Portland and natural (Louisville) cement mortars composed of one part of cement and two parts of Ohio River sand. Mixtures were also tested in which there was a partial or total substitution of limestone screenings, which contained a large quantity of very fine dust, for the sand. A few experiments were also made with mixtures of Portland cement and Ohio River sand in the proportion of one part of cement to one part of sand. The water under varying pressures was applied to 3-in. cubes and to hollow cylinders prepared from these mixtures. The cylinders were 8 in. in length, 6 in. in diameter and had a hole through the center which was 2 in. in diameter. The thickness of the mortar through which the water passed in the cubes was approximately 1½ in., and in the cylinders 2 in.

The first series of experiments were made more particularly to determine the effect of the substitution of limestone screenings and dust partially or wholly for sand in two to one mixtures. Cubes of the mortar were prepared in a 3 x 3 x 3-in. brass mold. At the time of making, a ⅜-in. iron pipe was set in the mortar so that the lower end was approximately equidistant from the six faces of the cube. The upper end of the pipe was threaded so that it could be attached to a pipe leading from a cylinder in which clear water was maintained at a constant pressure for the length of time it was desired to continue the experiment. The water, which seeped through the mortar, was collected and measured, due care being taken to guard as much as possible against evaporation. A suitable gauge was connected to the pipe leading from the cylinder to measure the water pressure.

The Ohio River sand which was used in making these motars was a quartz sand. It was clean, quite uniform in the size of its grains, but rather fine. The limestone screenings used contained a very large percentage of very fine dust. Atlas Portland cement was used in preparing cubes 1, 2 and 3, and Louisville cement in cubes 4, 5 and 6. The several cubes had the following composition, the proportions being by weight.

No.	Portland Cement.	Sand.	Screenings.
1.	1	2	—
2.	1	1	1
3.	1	—	2
	Louisville Cement.	Sand.	Screenings.
4.	1	2	—
5.	1	1	1
6.	1	—	2

The amount of water used in mixing the mortar was 10 per cent. in cube 1, 11 per cent. in No. 2, 14 per cent. in No. 3, 15 per cent. in Nos. 4 and 5, and 17 per cent. in No. 6. The age of the cubes when tested was seven days, having been kept one day in the air and six days under water. The thickness of the mortar through which the water was obliged to pass was at least 1½ in.

In the following tables the amount of seepage through the mortar has been expressed in gallons per hour per square foot of surface for the various pressures tried. In Table 1 the quantities of water passing through the mortar at a pressure of 50 lb. per square inch are given, and in Table 2 the amount of seepage measured on the same cubes at several different pressures are stated. In all these tests the pressures were carefully maintained constant for the full period of the experiment.

TABLE I.—RELATIVE PERMEABILITY OF CEMENT MORTARS OF DIFFERENT COMPOSITIONS TO WATER UNDER A PRESSURE OF 50 LBS. PER SQUARE INCH

Time Under Pressure, Hours.	Atlas Portland Cement Mortars. Flow in Gal. per Hr. per Sq. Ft. of Surface		
	No. 1.	No. 2.	No. 3.
3	Not measurable	Not measurable	Not measurable
5	“ “	“ “	0.04
16	0.16	“ “	0.04
	Louisville Natural Cement Mortars.		
	No. 4.	No. 5.	No. 6.
3	2.40	0.53	0.47
5	1.44	0.32	0.56
16	0.85	0.29	0.42

NOTE:—In those places where it is stated that the amount of seepage was "not measurable," the moisture on the outside of the cube was the only indication that water was passing through the mortar.

By comparing the amounts of water passing through these cubes, it is evident that the Portland cement mortars are more dense and considerably less permeable than the natural cement mortars. The introduction of fine limestone screenings to replace the sand appears to increase the density of the mortars, and the partial replacement of screenings by sand seems to be somewhat more effective than the total substitution.

In order to learn, if possible, what was the greatest pressure which these cubes would stand without permitting water to pass througa them, they were subjected to varying pressures for different periods. The results are given in Table 2.

TABLE 2.—APPROXIMATE MAXIMUM PRESSURE WHICH WAS APPLIED WITHOUT CAUSING AN APPRECIABLE AMOUNT OF WATER TO PASS THROUGH THE MORTAR.

Pressure Lbs. per Sq. In.	Time Under Pressure.	Rate of Flow in Gallons per Hour per Square Foot of Surface. 1.	2.	3.	4.	5.	6.
15	16 hrs	—	—	—	0.12	0.02	0.04
30	5 “	—	—	—	0.40	0.12	0.16
40	3 “	—	—	Not measurable	0.60	0.20	0.13
50	5 “	—	—	“	—	—	—
60	16 “	—	—	0.12	—	—	—
75	8 “	0.50	Not measurable	—	—	—	—
125	16 “	0.90	“	—	—	—	—

A study of these results seems to show that none of these mortars were absolutely impervious to water at the pressure applied to the different cubes, although the limiting pressures above which seepage began to be measurable are fairly well indicated. All of the Atlas Portland cement mortars were practically impervious at a pressure of 50 lb. per square inch. Cube 2 consisting of 1 part of cement, 1 part of limestone screenings and 1 part of sand, was nearly impervious at a pressure of 125 lb. per square inch. Cube 1 (1 part of cement to 2 parts of sand) showed a slight seepage even at 50 lb. pressure, while the limiting pressure for Cube 3 was practically 60 lb. per square inch. In the case of the natural cement mortars (Cubes 4, 5 and 6) it was necessary to reduce the pressure to 15 lb. per square inch before the flow of water ceased to be very appreciable. This same pressure (15 lb. per square inch) was also found to be the limit in a preceding set of experiments where, if this limit was exceeded, the seepage became quite marked.

Another series of experiments were made subsequent to those described above, in which mortar cylinders were tested; but only Atlas Portland cement and Ohio River sand were used in making them, the limestone screenings being omitted. The cement mortar was composed of one part of sand and one part of cement and was mixed with 10 per cent. of water. The test pieces were allowed to remain one day in the air, 27 days in water and then dried four days in the air before being tested.

The cylinders, as previously mentioned, were 8 in. long, 6 in. in diameter and had a hole through the center which was 2 in. in diameter. Pressure was applied to the interior of the cylinder through a perforated pipe of brass ½ in. in diameter and 12 in. long. The pipe was threaded on the outside a distance of 4 in. in from each end. Near the middle of the pipe four holes were bored to admit the water to the interior of the cylinder. The threaded portion of the pipe was provided with a pair of lock nuts at each end. When a test of a cylinder was to be made, the pipe was inserted in the central hole of the cylinder with two of the lock nuts set about 4 in. from either end. Upon the nuts rested two iron washers nearly 2 in. in diameter. Four or five sponge rubber washers a trifle over 2 in. in diamcter were then forced down on to the iron washers resting on the lock nuts within the cylinder. These served to plug the openings at either end of the cylinder. They were so adjusted as to project a little beyond the face of the mortar. A rubber cloth washer with a 2 in. iron washer to back it was then placed on each end on top of the sponge rubber packing. The latter was compressed by turning up the lock nuts on the outside back of the iron washer until leakage ceased. One end of the pipe was capped and the other attached to a pipe leading to a cylinder which could be placed under pressure. The interior of the mortar cylinder could thus be filled with water and subjected to hydrostatic pressure for any length of time desired. The area of the mortar under pressure was approximately 50 sq. in.

Several cylinders were tested but the data obtained with three of them are typical. The results are given in Table 3.

TABLE 3.—RELATIVE PERMEABILITY OF A ONE TO ONE PORTLAND CEMENT MORTAR UNDER VARYING PRESSURES.

Cylinder.	Pressure, Lbs. per sq. in.	Time Under Pressure.	Flow, Gal. per Hr. per sq. ft.
1	30	3 hrs.	.061
1	30	5 “	.036
1	30	16 “	.017
1	20	12 “	.00046
1	15	12 “	.00023
2	30	3 “	.047
2	30	5 “	.046
2	30	16 “	.020
2	20	3 “	.0061
2	15	20 “	.00076
3	30	3 “	1.228
3	30	5 “	.194
3	30	16 “	.059
3	20	12 “	.0106
3	15	12 “	.0053

Cylinders 1 and 2 offered practically the same resistance to the passage of the water, but Cylinder 3 was much more permeable. As the latter did not differ from the other two in composition or treatment after being made, it seems probable that the degree of compacting it received was not quite as great as the first two received. The same great difference in the permeability of two cubes which were tested at this time was noted. They were composed of one part of Atlas Portland cement and one part of sand, and their age was about one month. They were tested in the same way as were those described in the first portion of this paper. The results are given in Table 4.

TABLE 4.—RELATIVE PERMEABILITY TO WATER OF A ONE TO ONE PORTLAND CEMENT MORTAR UNDER A PRESSURE. OF 30 LBS. PER SQ. IN.

Pressure, Lbs. per Sq. In.	Time Under Pressure.	Flow, Gal. per Hr. per Sq. Ft. A.	B.
30	3 hrs.	Not measurable	16.0
30	5 “	“ “	3.4
30	16 “	“ “	0.5

NOTE.—Water was forced to pass through at least 1½ in. of mortar in order to escape.

A few experiments made on cubes of 2 to 1 Portland cement mortar, which had been tested when 7 days old and again after a lapse of about two months, showed that less water passed through the mortar at the later period, under double and sometimes triple the pressures formerly applied, than did at the earlier test. Another very noticeable feature of these results is in the gradual diminution of the volume of water passing, the longer the pressure is applied. This fact has been noted quite frequently before in both experimental work and in actual construction.

On two concrete tanks built by the writer, having a depth of 8 ft., it was found that the white deposit on the outside of the tanks where seepage had taken place was practically all composed of calcium carbonate. The explanation for the gradual reduction in the seepage through mortar and concrete would appear to be indirectly the result of the solution of the free lime, which is either present in the cement in the first place, or results from the decomposition of the cement during hydration. This solution of calcium hydrate on coming in contact with the air is carbonated and precipitates in the interstices of the mortar and gradually fills them up. The flow of water, therefore, becomes less and less as the passages are gradually filled up with insoluble carbonate of lime.

The conclusions which appear justified by these experiments and which are in general accord with those of other investigators, are as follows:

1. No mortar is absolutely impervious to water if placed under sufficient pressure.

2. The permeability of a mortar decreases with age; and differences in the permeability of different mortars of approximately the same composition, also largely disappears with age.

3. The permeability of mortars of approximately similar composition and made from the same grade of material, is probably more dependent on the compacting they receive when being placed, than on almost any other factor.

4. The continuous filtration of water through mortar tends to decrease its permeability. Obviously this is not true if the water contains constituents which would produce disintegration of the cement, such as might be found in sea water, in water containing a large amount of carbon dioxide gas in solution or in acid waters.

5. Mortars rich in cement are less permeable than mortars containing smaller proportions of cement to sand.

6. Mortars mixed dry are more permeable than those mixed wet, but this difference diminishes the longer the dry mixed mortar is subjected to the continuous filtration of water.

7. The thoroughness with which the sand and cement are mixed and the extent to which the voids in the sand are filled by the cement, or in other words, the greater the density of the mortar, no matter how attained, the less permeable it becomes.

Coal Lands in Iowa aggregating over 100,000 acres have recently been purchased by three of the principal Western trunk lines. The veins average 6 ft. thick and are 100 ft. below the surface.

The New Water Supply of Franklin, N. H.

Important additions to the water supply of the city of Franklin, N. H., have been made within the last two years under the oversight of Mr. F. L. Fuller, consulting engineer of Boston. In a report to the Board of Water Commissioners of Franklin, Mr. Fuller discussed in detail the requirements of the water system and the work accomplished, and the following information regarding the improvements has been taken from that report.

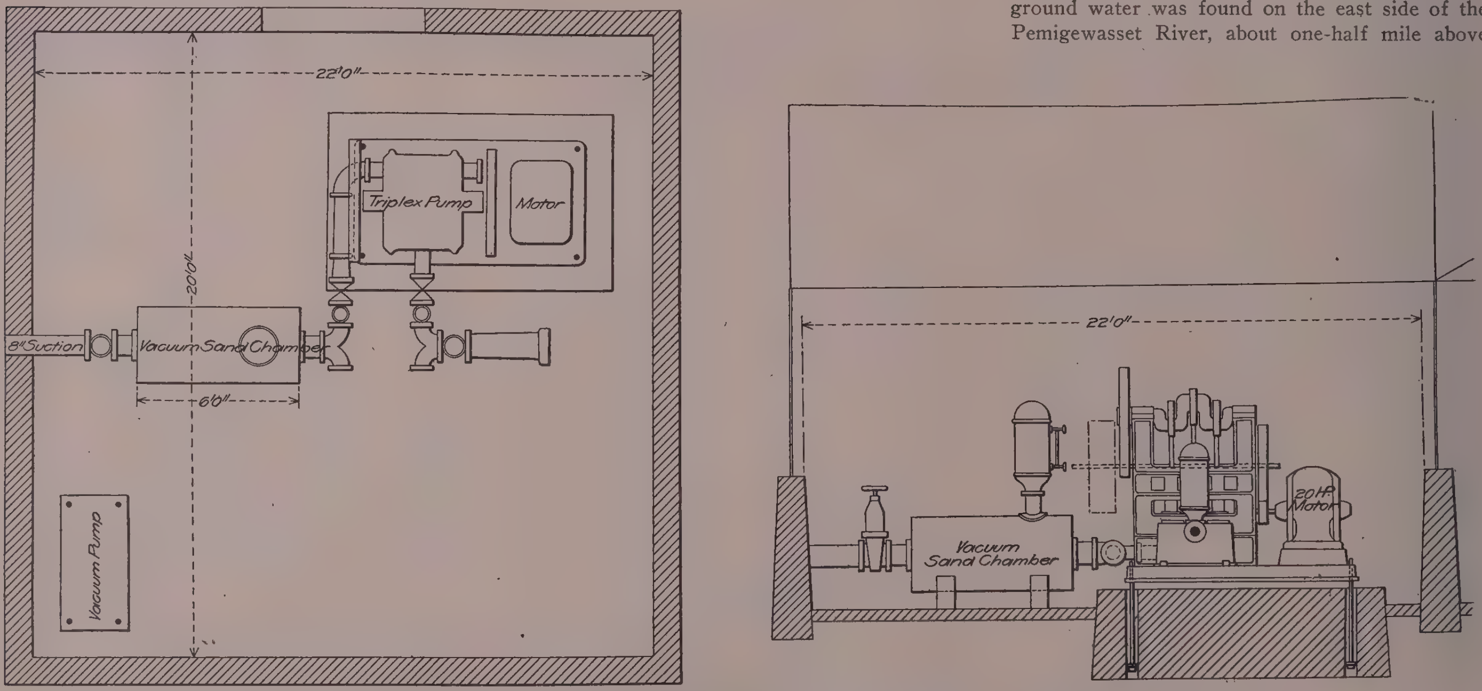
The first public water supply of Franklin, which is a community of about 6,000 inhabitants at the present time, was derived by gravity flow from the Coldbrook and Elkins Springs. No attempt was made to furnish fire protection, no water being held in reserve for that purpose. Small wrought-iron pipes were employed and only a comparatively small portion of the town was included in the system. In 1891 actual construction of a more complete water-works system began, and the Elkins and other springs became the source of supply for the new system. The water was drawn by gravity to a pumping station, and then pumped by water power to a covered masonry reservoir of 500,000 gal. capacity.

With an increase of population and the extension of the system the demand for water increased, and in 1904 it became necessary to investigate an additional supply. The consumption for the year 1904 was 89,232,500 gal., or a daily average of 228,900 gal. The estimated population using water was 5,400, bringing the average daily consumption per capita to about 51 gal., which moderate amount is probably largely due to the fact that all water takers are supplied through meters. Little or no water was being wasted. The yield of the Coldbrook and Elkins Springs varies from 60,000 to 200,000 gal. per day, and the deficiency was mostly made up from a spring on the north side of the Winnipiscogee River. Occasionally in the last two years, however, it has been necessary to draw water directly from the river.

Although Franklin has within its limits comparatively large streams, and the topography of the country is rough, it has been found impossible to obtain an ample supply of satisfactory water at a reasonable expense. From careful analyses by the State Board of Health it was found unsafe to use the water of either the Winnipiscogee of the Pemigewasset Rivers without purification by sand filtration, and the same requirements applied to the water from a body of water called Webster Lake. A few small brooks empty into these rivers, but none of them would furnish water of sufficient amount or satisfactory quality. There is no source, within a reasonable distance, whatever its quality, to furnish a gravity supply. Franklin also has no surface water supply which, in its existing condition, would be safe or suitable for the domestic needs of the city.

Ground or spring water was considered the most satisfactory of all supplies, if it could be obtained in sufficient quantity. If the ground water could be stored in covered reservoirs there was believed to be no liability of trouble from the growth of micro-organisms. Hence, a thorough investigation of the prospects of finding suitable springs was made. Before entering upon permanent work, from 25 to 30 favorable analyses of the water from the source proposed were made by different chemists. The locality selected was examined by Mr. H. E. Barnard, then chemist at the New Hampshire State Laboratory, and Mrs. Ellen H. Richards, of the Massachusetts Institute of Technology.

A suitable location for securing a supply of ground water was found on the east side of the Pemigewasset River, about one-half mile above a mill dam in that stream. This site is an area of comparatively flat land at an elevation of from 6 to 10 ft. above the ordinary level of the river, averaging about 200 ft. wide and bordering the river for about 3,000 ft. On the opposite side of the river is a steep hillside rising to a height of 90 to 100 ft., the great mass of the material being of fine sand, so that the larger portion of the rainfall runs off on the surface into the river and is lost as far as drawing it from the ground is concerned. However, the first well sunk on the site was 2½ in. in diameter and was driven to a depth of 37 ft. It yielded about 33 gal. per minute, or at the rate of 47,500 gal. per day. Numerous other wells were driven with varying success in the winter and spring of 1904-5. In many of the wells thin strata of coarse material were found which admitted water, but the prevailing condition was that of too fine material. Owing to the fineness of the sand the water was thoroughly filtered and the analysis showed it to be of excellent quality. It was thought that a long, narrow, covered gallery extending northerly



Plan and Elevation of Pump Room, Showing Sand and Air Intercepting Chamber.

nearly parallel with the river, and with the foot of the slope of the high land previously mentioned, might yield a considerable amount of water, and an excavation for such a gallery was begun, but on account of ledges and boulders the plan was abandoned.

At first, 2-in. pipe was used for making tests, but later 2½-inch pipe was used. The wash borings were made with a ¾-in. pipe. All driven wells now in the ground are 2½ in. in diameter. Test wells were put down by driving, with a heavy weight, a 5-ft. length of 2½-in. pipe, having an open end, removing the material inside with a drill and force pump. Another piece of pipe of the same length as the first was attached to the first one by means of a coupling and driven to the surface of the ground, the material being removed as before. Wash borings made by forcing a stream of water through an open end ¾-in. pipe, produced fairly good results to moderate depth, and in a much shorter time than by driving 2½-in. pipe.

Whenever a 2½-in. test well proved to be a good one, it was allowed to remain. In this way four 2½-in. wrought-iron pipe wells were retained, and now form part of the system. At six other points tubes or rings made of Portland cement, and sand or gravel, were used. These tubes were 30 in. in internal diameter and 2 ft. long and were furnished by the Rhode Island Cement Drain Pipe Co. An excavation of sufficient diameter to contain one of these tubes was made, and the tube placed in it. By excavating the material under the tube, its weight caused it to settle. When it reached the proper point another tube was placed on the first, and the excavation continued. After three or four tubes were in place in the ground they were secured by three iron rods holding them together in alignment. It was found difficult to sink the 30-in. tube wells to as great a depth as desired, and in order that they should not be pumped dry a 6-in. wrought-iron pipe was sunk by a water jet below the bottom of the 30-in. tubes. The suction pipes, generally of 3-in. wrought iron, were carried nearly to the bottom of these 6-in. wrought-iron pipes.

The largest well constructed was made of concrete blocks, and is 60 in. in diameter. An excavation was made by means of circular ribs and 2-in. spruce sheathing to a depth of 35 ft. The lower 18 in. of this excavation were filled with coarse screened gravel. Upon the bed of porous material was built a wall of concrete blocks laid with open vertical joints. The blocks were made in an iron mold, one side of which was removable. The mold was so shaped that the blocks had a curvature corresponding to a radius of 30 in., and of such a length that ten made a complete course, leaving the proper joint room. The blocks were made of 1 part Vulcanite Portland cement and 4 parts coarse sand obtained on the premises. The sand and cement were mixed with a small amount of water, the resulting mortar being rather dry. The mortar was then placed in the mold and well rammed. By unclamping one side of the mold the block was easily removed. After drying and setting about ten days, the blocks, which were 4 in. thick, 9 in. high and 18 in. long, were placed in the wall. The space between the back of the concrete wall and the plank sheathing, about 1.5 ft. for the lower and 2.5 ft. for the upper half, was filled with screened gravel, which allows the water in the surrounding soil to freely enter the well. The excavating was done by the Barker Well Co., and the concrete blocks were made and placed by the Savage Concrete Construction Co., of New York.

The result of the pumping tests in the spring of 1905 warranted the construction of permanent works. It was decided to build a small pumping station at the wells, a covered reservoir about 800 ft. from this station toward the city, a 12-in. force main from the pumping station to the reservoir and an 8-in. gravity main from the latter to the old pumping station at Bow St. The contracts for building the reservoir and the pumping station, as well as the pipe laying, were awarded to the Savage Concrete Construction Co., of New York. The new reservoir stores a supply of water which flows by gravity to the old pumping station on Bow St., when it is pumped to the old reservoir at Pleasant St.

The reservoir is 46 ft. in diameter and 20 ft. deep, and its capacity is 248,600 gal. The side wall is 3.5 ft. thick at the bottom and 2.5 ft. thick at the top. The wall is built of boulder concrete, the proportions being 1 of cement, 2 of clean, sharp sand, and 4½ of screened gravel, all by volume, to which it was allowable to add 40 per cent. of sound, clean boulders or field stone. The boulders were not allowed to come within 6 in. of the face of the wall or to touch one another. Vulcanite Portland cement was used in the wall, and Saylor's Portland cement in the roof. The latter has a dome shape. It is 10 in. thick at the circumference and 8 in. at the center, with a rise of 4.6 ft. To resist the thrust of the roof a steel band, 14.5 in. wide and 1 in. thick is imbedded in the concrete near the top of the wall. No cracks or settlements in the wall or roof have been observed. The wall was pointed with cement mortar where necessary. The bottom is of 6-in. Atlas cement concrete, the upper half being without coarse material, left smooth and trowelled. A Winslow electrical indicator shows at the Bow St. station the level of water in the new reservoir, and a 6-in. Ross Valve Co.'s balanced valve with float attached, placed in the pump well of the Bow St. station automatically closes when the water in the pump well reaches high-water level, and stops the flow from the new reservoir. The pipe laying connected with the driven well system was done by Mr. E. L. Wallace, superintendent of the Franklin Water Works, under whose general oversight most of the well work was done. The total cost of the reservoir was $3,558.40.

The pumping station is a concrete building 22 x 20 ft. in plan, 250 ft. east of the edge of the river. Its cost was $1,559, and the cost of making and placing the concrete blocks for the 60-in. well was $4 per vertical foot, and $1.50 per cubic yard for screened gravel filling behind the block wall. Mr. E. U. Boyden, of Boston, was the architect of the pumping station. The concrete was composed of 1 part by volume of Vulcanite cement, 2 parts of clean sand and 4½ parts gravel. The walls above the ground level were built 14 in. thick with a 2-in. air space. At the floor level the walls are 30 in. thick. The roof is covered with the best black Brownsville slate. The floor is of concrete, 6 in. thick.

The pumping equipment consists of a Gould's single acting outside packed triplex plunger pump having water cylinders 8 in. in diameter with 10-in. stroke. It is mounted on a cast-iron bed plate, which also carries a 20-h.-p. single-phase, 60-cycle, 110-volt Wagner motor geared to the pump by a rawhide pinion on the latter. The pump, when making 41 r.p.m. delivers 266 gal. of water per minute. In order to intercept the sand and especially the air which is liable to enter the suction mains, there is connected with the latter a riveted plate iron tank or chamber 5 ft. 7 in. long by 3 ft. 4 in. in diameter placed horizontally in the pump-room as shown in the accompanying illustrations. To this chamber is connected a water-jacketed pump with a 5x6-in. water-jacketed cylinder. This pump is operated by a 3-h.-p. Wagner motor, started and stopped by a float in the sand and air chamber. An influx of air into the chamber from the suction main depresses the float and starts the motor.

The pumping plant cost $2,380.34, and is supplied with electric power by the Franklin Electric Light and Power Company. Mr. F. P. Cutter, of Wakefield, Mass., acted as assistant engineer during construction.

Cleaning Waste and Wiping Cloths.

Some time ago the facility with which grease could be extracted from bones and similar refuse suggested the idea of cleansing similarly waste and wiping cloths used about engines and machinery. Mr. Godfrey Hall, of the firm of E. Cook & Co., Bow, England, conducted some experiments of this nature with such success that plans for a large plant were drawn for Messrs. Caird & Rayner. This plant, having a capacity of 100 gross of sponge cloths per week, has been built and is now being operated successfully by one man.

The working of the plant depends on the great affinity of benzine for grease of any sort, and on its volatility at ordinary temperatures. According to a description of the plant given before the Institute of Marine Engineers by Mr. H. Bertram, the dirty cloths are placed in a carrier, which consists of a series of perforated trays supported on a central perforated tube. This carrier is lowered into an extractor cylinder with a hinged cover, and a number of open and closed steam coils. The cover is closed and fastened tightly, and benzine is poured into the cylinder through a pipe connected to the bottom of another cylinder called the container. The benzine rises through the tube of the carrier, and passes through its perforations to the cloths. Heat is next applied by passing steam through the closed coils, and a dense vapor arises from the benzine combining with the oil and grease contained in the cloths; this condenses and falls to the bottom of the extractor, carrying the oil with it. This is continued until all the oil and grease have been carried to the bottom of the cylinder, the time required depending upon the quantity of cloths and the temperature of the steam in the coils.

A point is eventually reached when the temperature of the extractor will not permit the benzine to condense, and it consequently expands and fills the pipe leading to a condenser and then the condenser itself. A partial vacuum is formed and condensation is very rapid, owing to the low boiling point of the benzine. From the condenser the liquid falls into a separator, so-called, because, in a later stage, a quantity of steam is generated which it is necessary to remove from the benzine. From the separator it passes to the container and is ready to start on its round again.

After the benzine has been driven off from the extractor, a cock is opened in its bottom and its liquid contents allowed to run into a blower, where they are again boiled to drive off any traces of benzine and thoroughly agitated by jets of steam from an open coil. As the capacity of the blower is many times that of the extractor, a large quantity of mixed oil, water and carbon accumulated in it during the week. On Monday morning the lower part of its contents are allowed to run to waste, as a profitable use has not been found for it. The remainder, consisting of oil and finely divided carbon, is blown into tanks by admitting steam above its surface. The oil is run off from these tanks as required, treated by a cheap chemical process, and put to use again. The residue forms a lubricating grease useful for slow-speed shafting and like purposes.

The cloths are taken from the extractor by lifting out the carrier, and are hot, dry and dusty. After being shaken vigorously they are passed through a washer and then dried, when they are ready for use again.

The Trust Company of America Building.—II

Caisson Foundations.—The building has a steel framework 330 ft. high above the curb with twenty-seven main columns. The columns are loaded up to a maximum of about two and one-half million pounds, and have concrete piers carried by the pneumatic caisson process to solid rock at a depth of about 80 ft. below the curb. On the sides of the building the piers for the wall columns are made comparatively long and narrow and were sunk as close together as possible so as to form a water-tight wall enclosing the cellar and excluding ground water. Some of these caissons support one column and some of them support two columns, and others do not support any columns, but serve merely as retaining walls. On the fourth side, the building is adjacent to the Wall Street Exchange Building with its cellar enclosed by a similar caisson wall. Connections are made between these caissons and those in the Trust Building so as to complete the rectangle of the latter without enclosing its fourth side by new caissons. At one corner of the building where there is an irregularity in the outline, there is a special 14x31-ft. caisson supporting five columns. The other wall caissons have dimensions varying from about 5x14 ft. to 6x26 ft. The intermediate caissons are about 7, 8 and 9 ft. square. All caissons are rectangular and are built entirely of timber. The 14x31-ft. caisson had an estimated weight of over 20 tons and was too large and heavy to be brought to the site in a single piece; it was therefore built, assembled and match-marked at the contractors' yards and then taken to pieces and the materials trucked to the site where they were reassembled in 12 hours. All of the other caissons were built at the contractors' yards and were delivered complete on trucks; the largest one weighed about 12 tons and was drawn by six horses. They were delivered as required and were set in position by the traveler booms.

The caissons were made with four vertical walls of solid courses of timber driftbolted together. The corners were bolted to vertical inside timbers and the intermediate courses were usually made from 6 to 12-in. timber planed on all sides and calked. The upper and lower courses were of heavier timber to receive the roof and form the cutting edge, the latter being reinforced by a heavy angle.

The dimensions of the 14x31-ft. caisson and the stresses that it was proportioned for, were so much greater than for the other caissons that it was constructed with a special design. The walls were made with 12x12-in. timber and on all sides were stiffened by single and double intermediate vertical timbers. On the long sides these timbers divided it into three equal panels and at each panel point it was braced by full depth 10x10-in. knee-braces. These were bolted to an upper bearing piece with bent forged plates, and at the lower end were bolted between the vertical timbers and engaged the cutting edge in the plane of a horizontal transverse strut fitted against the latter and acting with a pair of horizontal tie rods which keyed the structure firmly together. Vertical struts and tie rods intersecting the upper ends of the knee-braces formed with the other members a queen post truss, giving great transverse strength to the caisson.

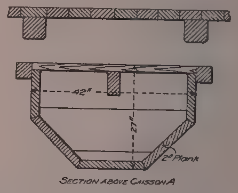
The upper course of the caisson was also knee-braced by horizontal angles intersecting at the center points of the short ends. On the long sides the lower course of timber was chamfered on the inner corner and the outer corner was shod with a 6x6x¾-in. angle with the vertical flange downwards in the outer face of the wall to make a cutting edge. On the short sides, the inner corner of the timber was trimmed just enough to fit the inside of a 12-in. channel bolted on, with the flanges up and with the cutting edge angle riveted to the back of the channel.

None of the caissons had permanent roofs, but after they were accurately seated, the material inside was removed by open excavation and trenching under the cutting edges until the caisson had descended about 4 ft. to ground water level. The roof of 2-in. horizontal boards was then built over the caisson supported on the solid walls and by temporary inside vertical shores. The first course of the concrete form was built above the roof, carrying up the walls of the caisson 7 or 10 ft. like a cofferdam, and in it a 6-in. layer of 1:2 Portland cement mortar was placed and over it 18 in. of 1:2:4 concrete, both mortar and concrete being carefully filled around the special lower section of the air shaft. After the concrete had set one day it formed a slab of sufficient strength to carry the wet concrete above it, which was usually filled in in courses about 3½ ft. deep.

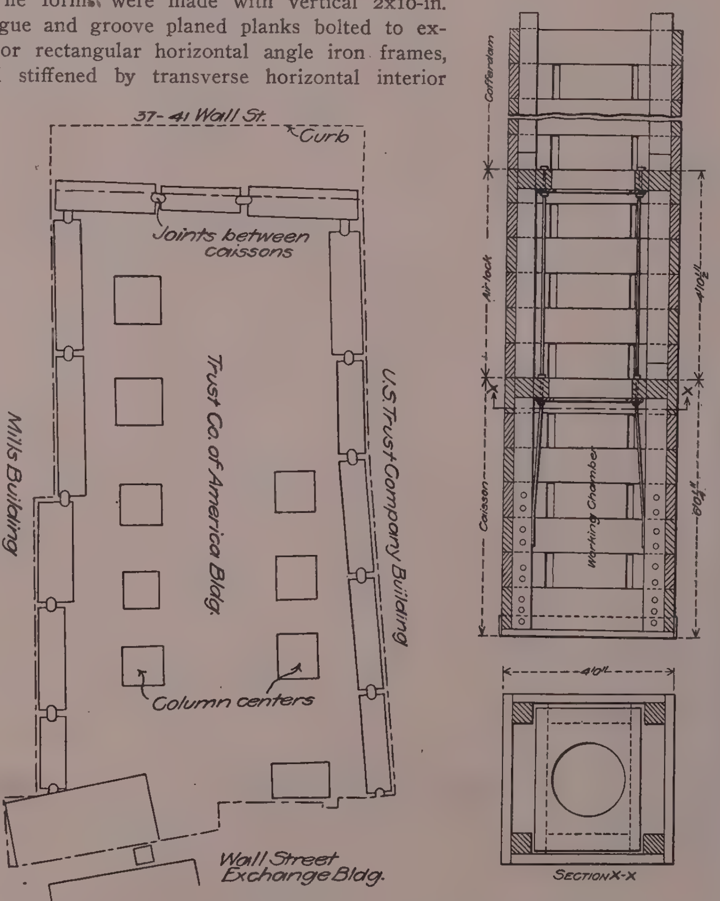
The forms were made with vertical 2x10-in. tongue and groove planed planks bolted to exterior rectangular horizontal angle iron frames, and stiffened by transverse horizontal interior angle irons connecting the long sides of the forms. The angle iron frames were placed about 3½ ft. apart and those at the upper and lower edges of the forms served as flanges for connecting the successive courses at the lower edge; where the form was seated on the caisson walls, the angle iron frames were braced inside by transverse angles, which were left permanently bedded in the concrete pier.

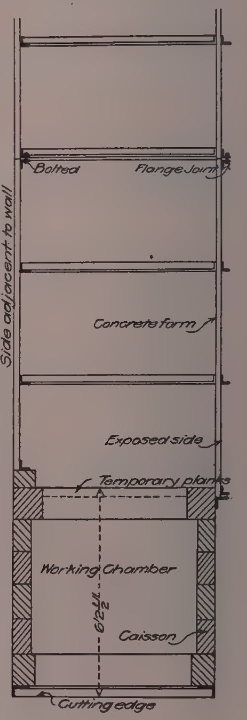
In order to reduce the pressure of the plastic concrete against the sides of the form, the concrete was made in comparatively thin courses with intervals of several hours between each course, which enabled it to set sufficiently to prevent cumulative pressure from the new concrete. One gang of concreters thus filled several forms, going from one to another and back again, and thus keeping up continuous work and allowing for intervals in each form. Two courses of forms were used for each pier, the lower course being removed and placed on top after the upper course was nearly filled with concrete, and so on. The forms were stripped at any convenient time after the concrete was 12 hours old. From a level 2 ft. above the deck to a level 1 ft. below the top of the pier, the concrete was made 1:2½:5 with Alpha Portland cement and 2-in. broken stone, and the pier was completed up to this level before caisson sinking was commenced.

Considerable economy was effected by removing the air shafts and using them over and over in successive caissons instead of leaving them permanently bedded in concrete as has been previously customary. The air shaft was made oval in cross section with a width of 30 in. and a length of 51 in. The regular sections 10 ft. long were built of ¼-in. steel made with three vertical joints which, like the horizontal joints, were made with inside bolted flanges. One side of the shaft was used for hoisting materials and was separated from the other side, which was used as a man shaft by a transverse latticed partition. The latter was built across the opposite curved end and its rungs consisted of the horizontal bolts passing through the vertical flange angles of the narrow end section of the shaft shell. The third vertical joint of the shaft was in the middle of the opposite end. When the concrete was laid the exterior of the shaft was thoroughly soaped and the short end segment was covered with oiled paper to prevent possibility of adhesion to the concrete. After the concreting was finished the ladder rungs were removed, thus unbolting the joint of the narrow section of the shell. This section corresponds to the key of an arch and was readily moved inwards, leaving the other two sections hinged together at the third joint. They were then easily collapsed and had ample clearance to be removed free of the concrete. All the shaft joints were made with rubber gaskets, and where the caissons were narrow and the shaft cut out large proportions of the cross section of the pier; the



Special Well Sheeting.

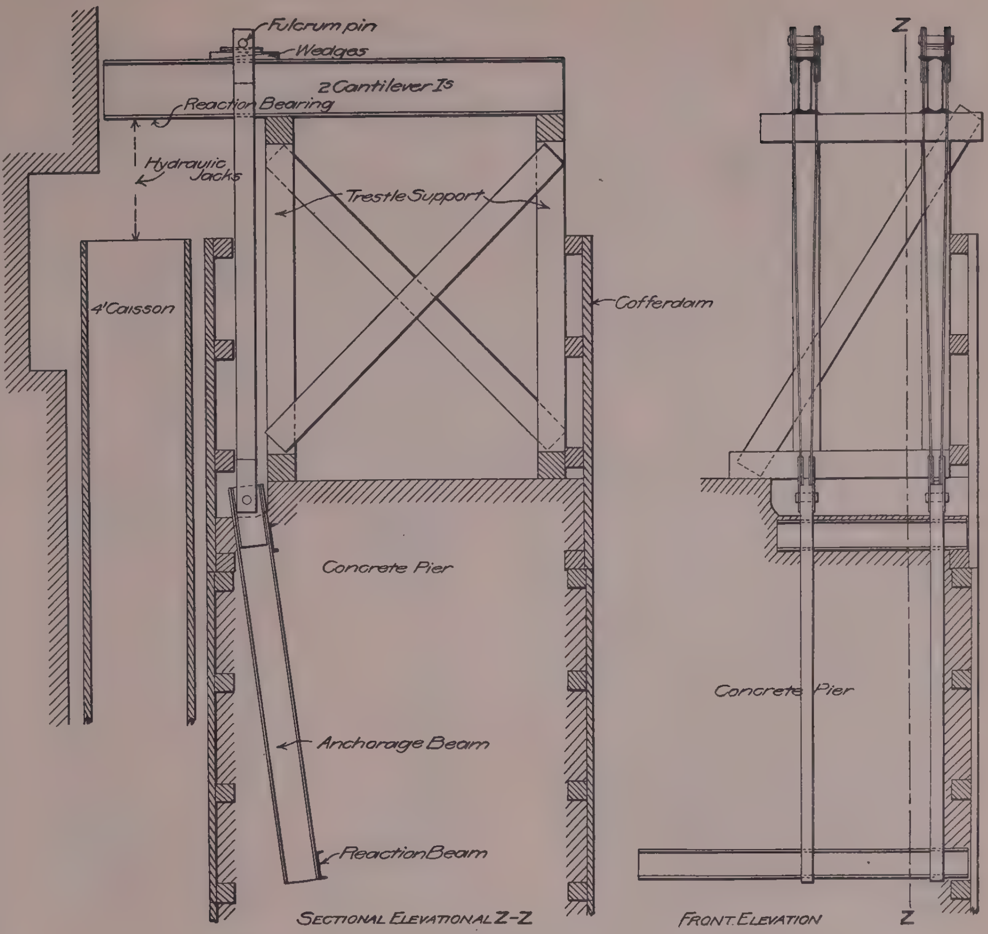




Location of Caissons and Connecting Wells, and Cross-Section of Caissons and Concrete Forms.

concrete on both sides of it was reinforced by horizontal twisted steel bars.

The caissons were sunk in the usual manner by excavation with pick and shovel and were loaded with 2-ton cast-iron blocks. About 400 tons of these were used on the work and were so rapidly handled by the derrick booms that they could be loaded or unloaded from the caisson during lunch time, and so did not practically hinder the operations. The compressed air for the caissons was furnished by a McKiernan, an Ingersoll-Sergeant and a Rand compressor, two of which had previously been used for sinking the underpinning cylinders. The maximum pressure in the caissons was about 20 lb. above atmospheric, and the maximum speed of sinking was about 25 ft. in 24 hours, the work being done continuously in eight-hour shifts. The caissons were sunk to hardpan through about 45 ft. of quicksand in which the cutting edge was always kept buried about 12 in. below the bottom of the excavation, thus insuring against any inflow of material. The sinking was effected entirely by the full weight of the concrete pier above it and the additional cast-iron ballast, special pains being taken to avoid blowing out the air in any case. The caissons were finally seated in very refractory hardpan from 3 to 5 ft. below its upper surface. The underpinning cylinders were carried through an average of 13 ft. of hardpan and seated on the rock because before the caissons were sunk it was uncertain what bearing would be considered satisfactory for the caissons, and the cylinders were carried to rock to avoid any possibility of leaving them at a higher level than might afterwards be adopted for the adjacent caissons. The piers and underpinning cylinders contained a total amount of about 3,000 cu. yd. of concrete which was mixed in one Smith and in one Ransome concrete mixer, and was delivered in 1-yd. bottom-dump steel buckets designed by the contractors.



Reaction Cantilever for Sinking 4-ft. Caissons.

THE COMPLETE FOUNDATION OF THIS BUILDING INCLUDING THE SHORING OF THE ADJOINING BUILDINGS IS BEING DONE BY THE FOUNDATION CO. 30 NASSAU ST.
FOUNDATION COMPANY

Steel Traveler for Handling Caissons; Elevated Dump Platform in Foreground.

The wall caissons were sunk about 12 in. apart in the clear to facilitate convenience of operation, and in order to form a continuous wall and exclude water from the interior of the building, it was necessary to bond them together and fill the spaces between them after they were sunk. To accomplish this, a semi-octagonal space was cored out of the centers of the adjacent ends of the concrete forms above the tops of the caissons. The cores were made of 2-in. planks fastened to vertical 4x4-in. side pieces that were connected by continuous tongue and groove horizontal strips as shown in the detail.

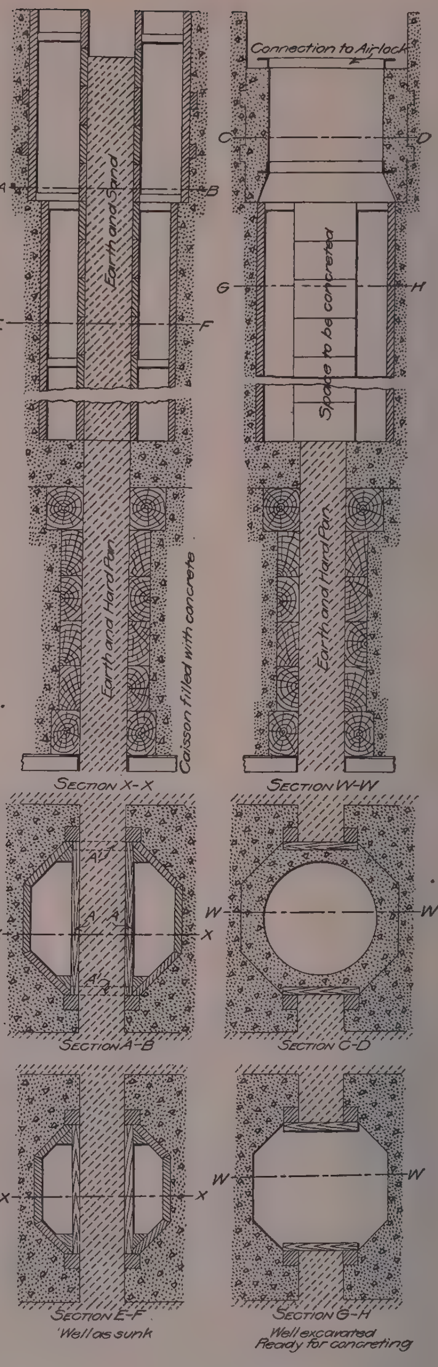
After both caissons were sunk, a man excavated the earth in the 12-in. space between the cores to a depth of 1 ft., and then removed the upper tongue and groove boards, *A A*, cut them to the proper length and nailed them across the vertical posts in the positions indicated by the dotted lines A^1 A^1, thus forming the upper section of an open sheeted octagonal well 42 in. in diameter between the two caissons. The excavating and sheeting was thus carried down about 4 ft. to the point where the thickness of each core was reduced 3 in., the width remaining 42 in., as before.

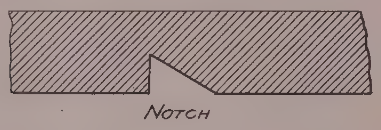
The core planks were all removed, leaving the face of the pier concrete exposed with two horizontal grooves in it corresponding to the 2x4-in. cleats on the outside of the core board. In this space a 2-ft. section of concentric steel shaft 30 in. in diameter was set in the top of the well, and the space around it filled with concrete bonded into the piers by the horizontal keys already mentioned.

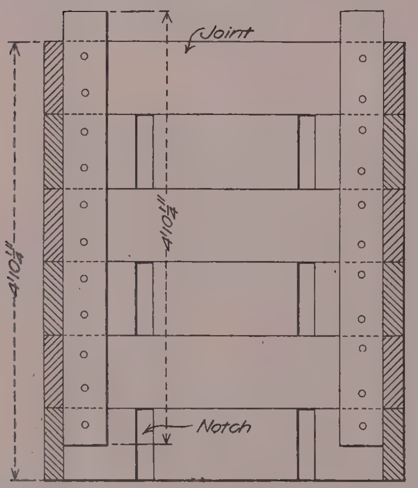
After the concrete was set, an air lock was connected to the upper flange of the steel shaft and pneumatic pressure was applied to the well. One man entered the lock and continued the excavation and sheeting of the well through the narrower cores down to the top of the caisson, a distance averaging about 40 ft. Here the cores stopped and the octagonal well terminated, the space below having a uniform width of about 12 in. between the ends of the caissons. Ordinarily the material at this level was hardpan, and little difficulty was encountered in removing it in the 12-in. space between the caisson by means of an ordinary post digger which removed successive lumps 6 or 8 in. in diameter. A man working on the roof of the caisson was thus able to excavate a small amount of material down to the cutting edge about 6 ft. below. After the excavation was completed, the well was filled with concrete dumped through the air lock and allowed to set under pressure.

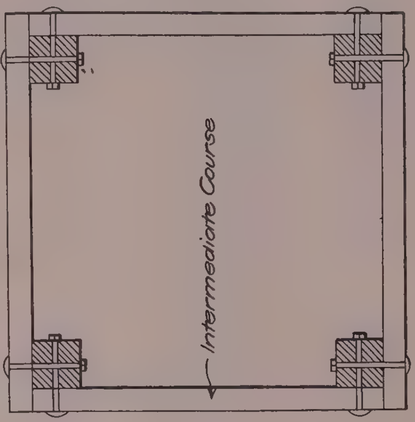
This method of connecting the wall caissons is novel in this work, and this is the first time in which the bond has been made under air pressure. In one case the adjacent caissons were sunk to different levels, one of them projecting about 10 ft. above the top of the other. Here the joint between caissons was made by a modification of the method above described. The core in the higher pier was made 27 in. deep so as to afford complete working space for one man, and no core was provided on the opposite pier. The end of the lower pier was a plain surface with two 6x6-in. sheeted vertical pieces on the face of the caisson opposite the 4x4-in. pieces in the adjacent core. A man entering the semi-octagonal core chamber removed successively the transverse planks *B*, from the top downwards excavating the material behind them so as to sheet the narrow spaces left between the two caissons.

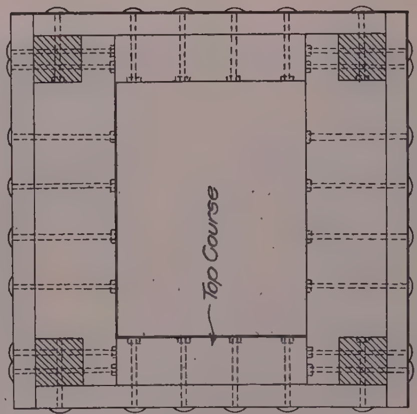
At one corner of the building a connection was made in a similar manner between the new caisson, and the oval caisson previously sunk for the foundations of the Wall St. Exchange Building. Near the opposite corner of the building the new caisson was practically parallel with and about 4½ ft. distant from the rectangular caisson in the Wall St. Exchange Building. Here the space between the caissons was filled by a special caisson 4 ft. square, in which provision was made for removing the opposite sides and putting the concrete out to the large piers on both sides of it after the caisson was sunk.











Details of 4-Ft. Cofferdam; 4-Ft. Caisson and Cofferdam and Well Sheeting and Excavations Between Caissons.

This caisson had a total height of about 36 ft. and differed essentially from the other caissons in that it was made integral with the concrete form or cofferdam above it, and that none of the concrete was placed in the form until the caisson was sunk to position. The walls of the caisson and cofferdam were made from 3x10-in. planed planks bolted to 6x6-in. inside corner pieces and calked. The cutting edge was joined by a 6x½-in. vertical plate projecting 2 in. below the plank, and the roof of the caisson was made with a solid course of 6x6-in. timbers anchored down by 1-in. vertical rods bolted to the walls of the caisson near the lower edge. The roof formed the lower diaphragm for the air lock, and the upper diaphragm was similar to it, and was anchored to it by a continuation of the vertical rods. Both diaphragms were pierced with a hole 3 ft. 6 in. in diameter, and were covered with ¾-in. hinged plates.

On the sides of the caisson and cofferdam parallel to the existing large caissons every alternate horizontal plank had two vertical grooves cut half way through the plank from the inside and about about 2 ft. apart. After the caisson was sunk, the two opposite lowest grooved planks were easily broken out, leaving a space 10 in. by 24 in. on each side of the caisson, through which the earth and sand were easily removed to the adjacent caissons, and the space immediately filled with the concrete. The next upper course of side planks were not grooved and were undisturbed. They were left in position to tie the sides of the caisson together. The second planks were notched like the first and like them removed and the spaces behind them were excavated and concreted, and so on. Alternate panels were thus opened to permit the excavating and concreting which was successfully carried on without much trouble and enabled the concrete filling of the caisson to be made continuous beyond its walls with the adjacent caissons and thus seal the space between them. The interior of the 4-ft. caisson was being concreted as fast as the excavation was carried up on the outside.

The dimensions of the 4-ft. caisson are so small that no space was available to receive ballast for sinking it, and as it was not located under the wall of the existing building, it was impossible to utilize the latter for reaction against jacking it down, as was done for the underpinning cylinders. An ingenious method of forcing it down was provided by permanently building into the adjacent caisson a pair of 15-in. I-beams 14½ ft. long, which were inclined slightly from the vertical and were connected at both ends by 12-in. channels. The I-beams were 6 ft. apart, but the lower channel was 12 ft. long, thus projecting at both ends and forming a reaction beam to distribute the stresses over a larger area of the caisson. Holes 4 in. in diameter were bored through the upper ends of the webs and received pins through jaw plates riveted to pairs of vertical 8x¾-in. bars about 18 ft. long. The upper ends of these bars engaged pairs of 24-in. I-beams and were connected by 4-in. pins with wedges driven between them and the top flanges of the I-beams. The I-beams were seated on a wooden falsework tower built on top of the pier and projected beyond it and the vertical bars, forming massive inverted cantilevers over the center of the 4-ft. caisson. A pair of 60-ton jacks were seated on top of the caisson and reacting against the ends of the cantilevers, forced the caisson down as material was excavated within it. As the caisson was sunk the permanent cofferdam was built up on top, course by course, keeping the upper edge in nearly the same position so that only a small amount of blocking was necessary to provide for the bearing of the jacks. By this method the 4-ft. caisson was successfully sunk and afterwards the vertical bars, the 24-in. I-beams, and the falsework tower were removed and the concrete was filled in at the corner of the large caisson ceiling at upper ends of the inclined I-beams as indicated by the dotted lines.

Mr. Francis H. Kimball is the architect of the building, and the George A. Fuller Co. is the general contractor. The contractor for the sub-structure was awarded to The Foundation Co., Mr. L. L. Brown, general superintendent, and Mr. G. R. Johnson, superintendent in charge.

(To be continued.)

The Testing of Coal.

A paper read before the Western Society of Engineers by A. Bement.

The purchase of coal under specification stipulating its composition, and the analysis of the fuel delivered under such specification, has now become an important feature of the coal business, and while the practice is of comparatively recent origin in this general locality, experience has demonstrated that there are certain features of specifications and analytical methods which may be corrected and improved. This applies particularly to the business transactions between the dealer who sells the coal and the purchaser who burns it. Another phase of the problem concerns the work being done at the coal-testing plant of the United States Geological Survey at St. Louis, the Illinois Geological Survey and the Engineering Experiment Station of the University of Illinois. The work of these institutions may be considered as that of research, to distinguish it from the inspection service.

It is the principal object of this paper to emphasize the necessity for improving the practice governing specifications and inspection, and also to suggest certain lines along which the research work should proceed, and it is fuel coal from the Eastern Interior coal basin that is more particularly considered.

The improvements and corrections which concern terms of specifications, and the inspection service, require that determinations of the following be abandoned: Moisture, volatile matter, fixed carbon, sulphur and evaporative power of the coal.

Every essential requirement of the purchaser may be fulfilled by confining specifications and tests to the three following characteristics; in fact, these three features alone will insure greater protection to the purchaser than obtainable under present general practice: Per cent. of ash in the dry coal, size of the coal, and heating power of the pure coal. The latter, according to prevailing practice, would preferably, of course, be expressed in British thermal units.

The reasons for the above recommendations are given under the following captions:

Moisture.—Moisture is a great and uncertain variable. It not only differs in various coal seams as the coal lies in the ground, but is affected in fuel as received in shipment, by conditions of weather, temperature and time the coal may be in transit. It is approximately correct, however, to say that each coal seam has a characteristic moisture content of its own, which is uniform over at least very considerable areas, but the after influences above mentioned change it, so that there is no assurance of what it may be except under specially defined conditions.

Therefore, the producer or coal dealer can exercise no control over moisture, and as the prime object of fuel inspection service is to insure that the customer is served to the best ability of the dealer, specifications and tests of moisture in coal delivered can offer no protection to the purchaser. As before mentioned moisture varies in different coal seams; for this reason it might appear that its determination would indicate the seam from which the coal came. This is not true, however, for reasons above mentioned. If tests are expected to identify the seam which produced the coal other means must necessarily be employed.

However, in coal inspection service, moisture has been found to be very high in cases where delivery is by wagon, which, owing to lack of sufficient explanation of phenomena at the time, may have led to the opinion that the dealer wetted the coal for the purpose of increasing its weight at the time of loading. If this is the practice, it necessarily complicates the problem, but the writer has had cause to visit every coal yard in Chicago, and never observed any wetting of coal or any appliances for such purpose. It would be a difficult and expensive matter to wet fuel as loaded, and require water pipes located along team tracks, which in some cases extend for several hundred feet, and with the finer sizes of coal it would necessitate a man stationed at each wagon to supply water as fast as the coal was loaded, otherwise it would be impossible to add any great amount, because simply flooding the top of a wagon load of screenings, for example, would only insure the upper surface being wetted as the water would not penetrate the mass. A further study of this matter has made it appear to the author, that this high moisture in wagon delivered coal, is due to the practice of wetting coal while it is being unloaded, very often done for the purpose of allaying dust, and to the water which is commonly added in the fire room for various reasons, both prior to the time of sampling.

This matter of moisture also complicates the problem as far as the inspection service is concerned, because it is impracticable for the inspecting company to have its sampler present when a wagon load of coal arrives, as it would entail an expense which the service could not bear. Also, sampling attempted at the time of unloading could not be properly performed, as the sampler would be unable to gather from a wagon at the sidewalk and prepare a sample as it should be done. Thus it appears, that the determination of moisture, even in wagon delivered coal, serves no useful purpose. With fuel received in cars, there could, of course, be no opportunity for adding water.

Volatile Matter.—No fuel coal of this locality is purchased for the purpose of making gas or for use in by-product recovery plants, therefore tests for this constituent are unnecessary, unless there be a great difference in the coal. "Volatile matter" is not very well understood. The best conclusion is that coal is a complicated hydro-carbon which breaks down in distillation into various fractions, depending upon temperature and duration of heating period, and that the difference in coal of this basin is not greater than that due to the varying effect produced by the volatilization test itself; or, in other words, the variation may be caused by the test rather than by the composition of the coal. Thus the volatile matter test is not sufficiently accurate to be of service in this case. It is, of course, true, that it would distinguish between bituminous, semi-bituminous and anthracite coal, but one may do this merely by inspection without any test whatever.

All coal of this basin is high in "volatile matter"; all will make smoke if burned in sufficiently bad furnaces, and all will make smokeless combustion and good efficiency in good furnaces.

Fixed Carbon.—In coal analysis the disposition is to follow precedent. Coal mining became an important industry in the East long before it did in this locality. Much coal in the Appalachian basin is suited to the manufacture of a high grade of coke, and the amount of residue, or, in other words, the coke obtained under the conditions of the process, is a matter of first importance. This has had the effect of emphasizing the importance of "fixed carbon," so that it has been looked upon in many quarters as of more moment than any other characteristic of coal, and these ideas, extending to our locality, have to a considerable extent influenced opinion regarding fuel. The same remarks regarding the uncertainty of the determination of volatile matter apply to that of fixed carbon, because the test for the former is the one giving data for the latter. If coke was made from coal of this locality, it would be possible under certain conditions, to make a useful application of the test for fixed carbon; inasmuch, however, as it is not the case, this constituent is only a troublesome and misleading feature of analysis.

Sulphur.—Sulphur has been in a measure treated in the past the same as fixed carbon. In metallurgical work it is of extreme importance, and in this connection has received more attention than with fuel coal. This has given a prominence to the sulphur determination which it would not otherwise possess, and upon the assumption that sulphur is in the form of pyrites or very largely so, the conclusion has been accepted that the amount of sulphur is an indication of the tendency of the ash in the coal to clinker. This is true, however, to only a slight extent; in fact, may not even be considered as a working hypothesis in this coal basin, because some of the seams which are the highest in sulphur produce the least clinkering, therefore conclusions regarding the behavior of the ash in this respect, are not justified by the amount of sulphur in the coal.

Evaporative Power.—This is something which should never, under any circumstances, become a feature of specifications or guarantees, for several very important reasons. In general, too many valuable factors enter into the problem. For example, boilers differ, some being more efficient than others, absorbing greater or less amounts of heat from the coal for reasons due to their individual superiority or inferiority. Then furnaces differ greatly; in some cases all of the volatile matter may be burned; in others, a large portion be wasted. Again, fire grates differ in like measure, causing varying losses of fuel which falls into the ash pits, and the combination of grate and furnace has an important influence on the excess of air which necessarily enters, and for this latter reason, also, the useful result obtained from the coal is affected to a marked extent. The above refers to the characteristics of the apparatus itself, but at this point another and most serious variable must be considered, that of the personal equation of the fireman or furnace operator; therefore it is apparent that in such a test, one may be unable to discover whether the result is due to the fuel, the peculiarities of the apparatus or its manipulation. In the case of a coal purchaser who does not realize these facts, the result is always attributed to the object in view, which is, in such instance, to determine the value of the coal. If he had wished to discover whether he employed a good fireman or not, the experiment would have been precisely the same, and he would have then considered the result due to manipulation. It is not only the above features which have an important influence, but the character of the load on the plant is a matter of great moment. In a works where boilers run steadily for 24 hours, the result secured, everything being equal, will be much better than in one where the work is necessarily interrupted by stoppages at noontime, shutting down at night, or with peaks of load as in electric railway service. Any one of the foregoing causes may exercise a greater influence on the evaporative result secured than that due to variation in fuel.

It is not intended in the above to imply that coal burning experiments are not useful, because there are some things which may be settled as affecting certain plants; for example, fuel high in ash generally costs less per ton than that containing less ash, and it might be a question which would be the most economical to use; or, the matter of the most desirable size of fuel may be in question. These two are the only features which can be settled by burning coal under a boiler, and they should not be made part of a specification or guarantee, but used entirely for the guidance of the fuel user in selecting the best grade.

The behavior of coal under boilers is a problem very little understood, because it is the result of many variable influences, and for this reason it is often felt that the calorimetric test is unreliable, which, however, is not true, because the calorimeter does its work very accurately as far as the coal itself is concerned, its efficient utilization in service is influenced only by the amount and fusibility of the ash associated with it and the size of the pieces of the fuel.

It is well in this connection to direct attention to the fact that there is a feeling more or less prevalent, that coal from different localities or seams, may possess some undefinable peculiarity in its chemical combination, which causes it to behave differently under a boiler than it would in a calorimeter. Such conclusion is untenable, because the process is identical in each case, that of combination of oxygen with the carbon, hydrogen and sulphur of the coal, and this combination cannot be any different under the boiler than in the calorimeter, unless certain influences due to the peculiarity of the boiler apparatus and its manipulation assert themselves, and it is the disposition as far as the coal is concerned, to blame it for effects which are due to causes other than its chemical composition. It is well in this connection, to call attention to the fact that the heating power of the coal proper, or, in other words, the pure coal in Illinois, only ranges from 14,000 as a minimum, to 14,750 British thermal units as a maximum, and that about 80 per cent. of the fuel produced ranges between 14,000 and 14,500 British thermal units per pound. Thus the enormous variation found in service under boilers as far as the amount of water evaporated per pound of coal is concerned, is mostly due to the characteristics of the apparatus, the manipulation, and to the size of the coal and the amount of ash associated with it.

Thus it is very clear that specifications or guarantees covering amount of evaporation per pound of fuel or per cent. efficiency, are not only useless, but troublesome, to the purchaser and dealer.

The three approved tests may now be considered, and while in the above classification they are presented in the order of greatest importance, it will be convenient to change their arrangement.

Pure Coal.—For better understanding, it is desirable to consider coal as the chemical combination of certain elements which are principally heat producing. The association of ash and moisture with these results in an aggregation which may be designated as fuel, although generally called coal, which, from this standpoint, however, is not correct, because neither ash nor moisture produce heat. The expression, pure coal, is the equivalent of what has erroneously been called combustible, the pure coal containing all of the combustible matter, and some water of composition and nitrogen which are not combustible; but as these two ingredients are associated chemically with the combustible, the ultimate conception of coal is covered by this term, pure coal. Thus in the heating power determination, it is more to the point to base results on the pure coal than on any of the fuel mixtures, illustrated as follows: Let it be assumed that in one case the B. t. u. per pound of dry coal is 13,250, and in another 12,450, from which it would appear that the two lots of fuel were different; but if the percentage of ash content in each is known, and the first sample contained 7 per cent. and the latter 12 per cent., it appears that each sample has a pure B. t. u. of 14,250, or, in other words, that the coal is the same in each, there simply being more ash associated with it in one case than the other. Basing the heating power determination on pure coal has another very important advantage, as it enables one to judge of the accuracy of analysis, because when the heating power and the source from which the coal comes is known, there is evidence indicating whether or not the analysis has been correctly performed, because, if it has not been, it will be shown by the B. t. u.

Ash.—An important reason why ash should always be considered as a percentage of the dry coal instead of the moist fuel is, that like the B. t. u. determination, unless it is placed on some common basis, proper comparison cannot be made on different lots of fuel; for example, in two samples, the moisture may be 8 and 13 per cent., and ash in the dry coal 10 per cent. in each, but expressed on the moist coal basis, it appears that one has 8.7 and the other 9.2 per cent. of ash, and it would seem that one of the fuels contained more than the other. In this connection the fact should be borne in mind, that no one burns moist coal; the moisture is evaporated and passes away; in fact, dry coal is not burned, the ash remaining, it being the pure coal which enters into the process of making fire.

Size of Coal.—As a general proposition, the value of fuel increases with the size of the pieces, so that a very fine "duff" is of little use, but as the pieces become larger, the actual value increases in a greater ratio than does the heating power, and this continues to egg size and lump. Thus smaller pieces containing the same amount of heat per pound as larger ones, are of less value than the larger coal.

The size of the pieces of coal exercises an important influence, not only on the capacity which may be produced by a boiler, but on the resulting efficiency, and the best size to be used in a given case is dependent upon many conditions, such as the strength of draft, kind of stoker or grates, method of firing, etc., and the selection of the proper size of fuel or the method of utilizing the available size, often affords an opportunity to effect important economies.

Sampling.—One feature of the matter, referring especially to coal inspection service, is proper and reliable sampling. In very many cases the coal inspection service is rendered by a company, which, while acting as the purchaser's representative, is depended upon to furnish the seller with reliable reports concerning the composition of coal supplied. Under such conditions, it is absolutely necessary that not only shall the inspecting chemist be both competent and reliable, but that he shall be as fully responsible for the collection of the samples as he is for the analytical report, and it is also absolutely essential that the purchaser of his employes shall not be allowed to sample any coal or assist in the sampling, because under such conditions, the chemist may not know whether the report which he makes is correct or not, and it is well to emphasize the fact that the sampling is of as great importance as the analysis itself.

Referring to the branch of the subject before mentioned as that of research, there has been in operation for some years at St. Louis, what has been designated as a fuel testing plant, under the direction of the United States Geological Survey. Its principal published work so far, however, has been largely confined to "tests" under boilers, which have been thought to show the "real steaming value" of the fuel. The author's remarks above regarding testing coal under boilers, will refer to this branch of the work.

Probably the reference to coal in the plural has done much to cause confusion, because it has led people to believe that there are very many "kinds" of coal. For example, fuel from Herrin and Carterville in this state, would, according to this, be considered as different "coals," when, as a matter of fact, they are from the same seam, and the most exact analytical tests so far made, do not indicate a difference. The amount of ash associated with the coal may or may not vary, but the coal is the same, and it is coal and not coals, otherwise, every mine would produce a different kind of coal, notwithstanding the fact that seams in Illinois sometimes run through an entire county without it being possible to detect any variation in the quality; therefore, the expression, kinds of coal, which has been used frequently in connection with coal testing work, should not only be better defined, but limited in its application to those cases where there is a real difference, which, as is well known, does exist; for example, it must be conceded that anthracite and bituminous are different kinds of coal, but the most liberal application to this coal basin would allow only two kinds, which are the block coal of Indiana, all the remainder being bituminous, the latter also including what is known as semi-block of Indiana.

The state of Illinois has made an appropriation covering cost of investigations to be conducted by the Engineering Experiment Station of the University of Illinois, and there is certain important work which it is hoped will be undertaken, having a bearing on the values of fuel, studies tending to define the laws controlling the influence due to the size when burned with some different kinds of stokers or grates, and similar studies to ascertain corresponding effect due to varying amounts of ash in coal, also degree of fusibility of such ash.

The recently established State Geological Survey will present by all means a very much better coal report than has so far been published by any state, and it will be a great help to the purchasers and producers of coal, if certain values as affecting heating power, ash and moisture are authoritatively presented. As before mentioned, the three essential items are heating power of the pure coal, percentage of ash in the dry coal, and moisture. The B. t. u. values would be the simplest of the three, as these results would apply to pure coal, and which is, no doubt, practically a constant for a particular locality of a seam, therefore, once determined, it will not be necessary to repeat tests. Establishing ash values would be a more difficult matter, because it would not only involve ash in seams as the coal lies in the ground, but the various grades of fuel shipped from those seams. Ash, however, at the mine, would be the same in quantity as when received by the consumer. Securing moisture values would be a far more complicated problem, because of greater variation due to temperature, weather condition and time in transit. For these reasons, it is difficult to arrive at any conclusion regarding the amount of work which may be justified in the establishment of such values. Some idea of the complication may be illustrated; for example, the washed and sized coal shipped so extensively from Williamson County has a characteristic moisture content due to the difference in the size of the pieces, the larger ones being drier, and these moisture contents vary over wide ranges between summer and winter, and also according to the length of haul; thus at least average moisture values would be needed for each size, at the city where the coal was received.

A recent expression which has come into use, is that of "air-dried coal," which is based upon allowing the sample to become dried in the open air of the laboratory, the idea being that this shows the fuel as it would reach the customer. No standard conditions, however, appear to be employed in this air-drying, and if there were, the values obtained thereby do not indicate the amount of moisture in coal when it reaches the consumer. Some samples of air-drying on Illinois coal have shown the moisture as being between 5 and 6 per cent., when as a matter of fact the same coal is never received with less than 7 and in the winter time it is very much more. This moisture value should be abandoned, as it serves no useful purpose, tending only to increase existing confusion and misunderstanding.

Operating Results at the New Baltimore Turbine Power Plant.

Details of the Gould St. power station of the Baltimore Electric Power Co., which has now been in operation for over a year, were presented in the Engineering Record for July 21, 1906. The plant has many interesting features of design, in building arrangement, details of apparatus and arrangement of auxiliaries. It is laid out on the unit principle, consisting of a continuous longitudinal turbine room, with transverse independent boiler houses attached opposite each two turbines. Each boiler room contains eight boilers with the necessary auxiliaries, and each steam turbine and the corresponding four boilers opposite form an independent power plant unit of 2,000-kw. capacity. The original installation consisted of three units, 6,000 kw. in all, but the load on the station has already grown so large that an immediate extension is necessary.

Records of operation of this plant have been kept with care from the start for the purpose of comparison of the service rendered by the turbines, with those of reciprocating-engine-driven plants. The turbines had been operated practically continuously from the time they were completed until last June, never having been dismantled for examination of working parts and determination of condition. The following notes, abstracted from a report by Mr. B. S. Josselyn, vice-president and manager of the company, describe the condition of the turbines and state the fuel and water consumption.

The general condition of turbine No. 2, when opened up, was found to be as good as when first installed. No fractures, warping, misalignment or other evidences of undue stresses were visible, or deterioration of the steam surfaces of cylinder or spindle after 11 months of operation. The machines retained their position on the foundations, without the necessity of anchoring by bolts or other means.

No blades were found missing in either cylinder or spindle and although saturated steam had been used the blading was in excellent condition. No evidence of erosion from entrained water was visible, both edges of the blades and the steam surfaces being intact. From the appearance of the blade ends and opposing surfaces of the cylinder and spindle barrels no rubbing had ever taken place. Some surface oxidation was noticeable, due to condensed steam remaining in the cylinder while the machine was out of service; this was entirely superficial, however, and had not impaired the smoothness and accuracy of the blade curvature.

No wear had developed on either shaft or bearings and over the entire wearing surface of the latter the original marks of the scraper tools were clearly visible, showing that the rotating element was supported on oil films and that no frictional contact between the opposing surface of the journal took place. This result was probably due to the effective oiling system employed —positive continuous flow—the journals being continuously flushed with oil under a few feet pressure head.

The turbine type water packing glands developed no erosion or side wear, and effectively prevented the entrance of air into the condensing system as evidenced by the high vacuum carried and the small amount of work required of the air pumps.

With the exception of a pair of inexpensive knife edges that were replaced, although but slightly worn, the entire governing mechanism remained intact. No lost motion or other irregular working developed, and the governing was as sensitive and positive as originally.

Since the plant was in normal operation the service rendered by the turbines was of a very satisfactory character. There were no troubles whatever of a serious nature and practically no repairs had been necessary. The plant gave 24 hours service, with load varying according to demand for light and power, and the several turbine units were operated in such a manner as to most efficiently sustain the load anticipated. As one unit had ordinarily been sufficient for even peak loads, the generating plant was operated for the most part considerably below its rating. At the time the report was made, in June, 1906, the station load factor varied from 12 to 15 per cent. during week days, down to 5 to 8 per cent. on Sunday, but next winter, however, a much higher load factor is expected.

All three turbines have shown ample capacity, a load of over 2,200 kw. having been sustained without the assistance of the secondary valve which provides at least 50 per cent. excess capacity when desired, as shown by the original shop tests. No difficulty has been experienced in synchronizing and operating in parallel any of the turbine units. This operation is entirely under control from the switchboard, for which purpose a small motor driven synchronizing mechanism attached to the governor is employed. This has proven a desirable feature.

The turbines have proved well suited to high vacuum, although this operating condition is not essential to satisfactory performance, and no extraordinary trouble has been experienced in providing a vacuum within 1 in. of the barometer, particularly during cold weather. This condition is no doubt enhanced by the absence of sources of air leaks; in fact, it has been found possible to run the air pumps at much below their rated speed. When operating with good vacuum the low temperature of the turbine casing at the exhaust and of the water in hot well indicates effective utilization of steam. Normally the exhaust temperature approximates 100° Fahr.

All the troubles thus far encountered in the operation of the turbines have been of a minor character. At the outset bearing, No. 3, of turbine No. 2, ran warm, which was due to a shortage of oil in the lubricating system. This was easily corrected by adding the proper quantity of oil; since then no hot bearings have occurred. A copper expansion joint, located on one of the equalizing pipes, developed a fracture, but without any trouble resulting. This was replaced by a new part. One of the copper cooling coils for the oil system likewise developed a fracture, resulting in a small loss of oil before the defect was discovered. The leak was soon repaired and these cooling coils are now located in the turbine basement where they are readily accessible. The few oil leaks at first encountered in the oil piping have been corrected by sweating joints.

Notwithstanding the low load factor above mentioned (12 to 15 per cent.) the station for the month of May averaged 3.36 lb. of coal per kw-hour generated, including all coal for banking and changing boilers. This coal consisted largely of bituminous mine cuttings, very friable and resembling slack. With a better grade of coal a consumption of 2.6 lb. per kw-hour has been recorded.

The corresponding water consumption of the station for the month of May at this load factor averaged 23.9 lb. per kw-hour including all auxiliaries. All of the condensed steam from the turbines is used for boiler feed water, the small amount of make-up water necessary being drawn from the city mains. An analysis of the condensed steam sent to the boilers shows it to be quite free from oil and mineral impurities, with the exception of a trace of salt from condenser leakage.

In considering the above results the important effect of load factor on plant economy must not be lost sight of. Within small ranges the economy increases with the load factor, i. e., fuel burned per kw-hour decreases as the station load increases. With the large increase in load anticipated for the coming winter season a material decrease in the present fuel rate is expected.

During May the actual evaporation (from a feed temperature of 180° Fahr.) averaged 7.11 lb. of saturated steam per pound of coal. With the present low grade of fuel the average evaporation is 6¾ lb.; on a better grade of fuel it has reached 8 to 8½ lb.

From an operating standpoint the steam turbine motive power equipment has, in the opinion of the officials of the company, proved eminently successful, entirely suitable for central station service, permanent in construction and adjustment, and economical of steam especially at low loads. It is found simple to operate, requiring less attention, both skilled and unskilled, than a reciprocating engine plant of corresponding size and they have no hesitation in recommending turbine machinery for this service.

Sulphate of Iron as a Coagulant in Water Sedimentation.

Extracts from a paper read before the Central States Water Works Association by W. A. Patton.

The plant I operate supplies the cities of Ashland and Catlettsburg, Ky., and Kenova, W. Va., and there are about 16,000 persons on the water line. The pumping station and reservoirs are located at Catlettsburg, and we take the water from the Big Sandy River, about one mile above the junction of the Ohio and Big Sandy rivers. While taking the water from this river relieves us of the sewage pollution of the Ohio River, yet so far as turbidity is concerned, the supply must be classed as one of the Ohio valley type, and it was to overcome the objectionable turbidity that the plant was equipped for the use of sulphate of iron. About 2,000,000 gal. of water are pumped a day to the reservoirs, four in number, in which from six to eight days' supply is carried. The water is pumped into the bottom of one end of pool No. 4, which is termed the settling basin, and it is then drawn from the surface of this pool at the other end, 1,000 ft. distant, through a pipe into the bottom of pool 3, which is termed the middle pool, or second settling basin. From the opposite end of pool 3, 1,000 ft. distant, the water is drawn from the surface over a waterfall, in order to aerate it, into the third pool, which is termed No. 2, and has a connection in the bottom with the pipe system. Pool 1 is a small basin holding only 1,500,000 gal. of water, it being the first one constructed and is now used for what it is worth as extra storage only.

In designing the reservoir system the natural sedimentation and aeration was expected to give satisfactory results, but in this we were disappointed. After investigating the various processes for purifying water, as best we could with the means at our command, we preferred the lime and iron process. The quantities of lime and sulphate of iron used are from a fraction of a grain to two grains of each to a gallon of water, and these are precipitated in the settling basin so that neither reaches town. Should there be ten times that amount of each added and all of it reach the consumers, no harm would result from the use of the water for family purposes, as many spring waters that are drunk extensively contain more than ten times the quantities of lime and iron that we use.

The sulphate of iron and the oxide of lime are both soluble in water; they are dissolved separately and are injected into the discharge pipe of the pump at different points. In the passage through the pipe to the settling basin the chemical action takes place, resulting in the formation of the insoluble oxide of iron and the almost insoluble sulphate of lime, and being insoluble they are deposited by natural sedimentation in the settling basin, thus taking from the water the added chemicals, and in the sedimentation they not only carry down the turbidity but largely destroy the objectionable bacteria.

For the first several months our experiments were extremely crude, but crude as they were, the results were sufficiently satisfactory to assure us we were on the right road to a successful solution of the problem. During this period many changes in the method of operation were made, until to-day we believe we can take care of any emergency. The only way to judge any process is from the results, and if the finished product as delivered to the consumers during the past year were to be taken as a basis of judgment in our case, it would not be a recommendation for our system; but in explanation of this we can give good and sufficient reason for the water not being up to the standard at times, the causes always being from accidents beyond our control at the time. These accidents have since been guarded against and should not be considered to detract from the system we have adopted.

The entire process being experimental, but one pump was at first equipped to handle the lime solution. This was an ordinary boiler feed pump with iron plungers, but as the sulphate of iron rapidly attacked the plungers, brass plungers were substituted. These proving no better, the pump was changed into an inside packed piston type using hydraulic packing, which was more satisfactory.

As long as the requisite amount of lime solution, properly stirred, was delivered, satisfactory results were obtained, but when the lime pump broke down, as it did on numerous occasions, our brightest hopes for delivering clear water would go glimmering, because the muddy water that we would pump during a short break-down would be sufficient to highly color a whole reservoir of clear water, perhaps a five or six days' supply, thus making it necessary to deliver turbid water until the reservoir supply was exhausted. To overcome this trouble, a second pump of our own construction was installed, and the working of it was so satisfactory that another of the same type was built, and now there are three pumps equipped for service, one for use, and the other two held in readiness for any emergency.

The next trouble was in keeping the lime solution properly stirred, because if it is not kept continuously in a creamy condition the treatment of the water will be without good results. To accomplish this several devices were tried, each of which would accomplish satisfactory results during the experimental stage, but when put into continuous practice would cause turbid water in the reservoir time and again. To overcome this a regular steamboat paddle wheel was installed in each lime tank. The wheel was 6 ft. in diameter and the length of the tank, and reached to within 6 in. of the bottom. On the shaft of the wheel there is a sprocket chain connecting it with a countershaft on top of the tank, driven by a belt connected with an engine. This device has been found to be very satisfactory, as the solution in the tanks is continuously in a creamy condition and all of the soluble portion of the lime is pumped from the tank.

The equipment for preparing the chemicals consists of two concrete tanks, each 12 ft. square and 10 ft. deep for the lime solution, with a concrete mixing tank 5x8 ft. by 3 ft. deep, and two concrete tanks, each 10 ft. square, and 10 ft. deep for the iron solution, with a mixing tank on top, the same as for the lime solution.

In practice each tank is filled to a depth of 9 ft. and drawn off to 1 ft., making 8 ft. working depth in the tank, the amount of one batch of solution. In this 8 ft. of water 200 lb. of chemicals are dissolved, the chemicals being placed in the mixing tank and water passed over them which is decanted to the storage tank until the required depth is obtained. Then to obtain a solution of one grain per gallon 6 in. are pumped from the tank per hour while running the water pump at the rate of 84,000 gal. per hour. To be exact this would require 192 lb. of chemicals to each batch, but as lime comes in 200-lb. barrels and copperas in 200 lb. sacks, one barrel of lime and one sack of iron are considered sufficiently near for all practical purposes for each batch. To increase or decrease the quantity of chemicals to the gallon it is merely necessary to increase or decrease the number of inches taken from the tanks.

The lime solution is pumped throughout a 2-in. pipe into the discharge pipe of the large pump, while the iron solution is run by gravity from the iron tank to the suction pipe of the large pump. We have been using the solutions for almost two years, and the 14-in. discharge pipe, 4,000 ft. long, from the pumps to the reservoirs, is free from any incrustation. About 4 ft. from the end of the discharge pipe three baffles were built the depth of the settling basis and 2 ft. apart, through which the water has to pass in order to impart to it a whirling motion, and while there is no deposit in the discharge pipe and but little between the baffles the heavy deposit is just beyond the baffles, having reached a depth of 7 ft. in two years. The benefit of this treatment can be appreciated when it is known that after a little less than two years' pumping 2,000 tons of sediment were taken from the settling basin, pool No. 4. About one-third of the year the water is clear in the river. Therefore, in 250 days 1,000 tons were pumped, or an average of four tons a day, which at two million gallons of water a day will show a deposit of 28 grains of sediment from each gallon of water.

Numerous tests were made to see if the alkalinity of the water was increased by the use of the lime, using the stearate of soda or soap solution test in a burette, and the increase was found to be scarcely perceptible, only seven parts per million. The water had not been examined from a bacteriological standpoint, but in 1905, when typhoid fever was epidemic throughout the Big Sandy Valley, from which the supply is taken, and the mortality was running unusually high, there was scarcely a case of typhoid fever among the 16,000 persons on the water line but what could be traced directly to an origin in the country, and not on the line.

Letter to the Editor.

The Panama Canal Contract.

Sir: It seems to me that there is one feature of the proposed form of contract for the construction of the Panama Canal which is not sufficiently emphasized in your remarks on the subject, on Oct. 13 and 20. In the proposed form, printed in your issue of Oct. 20, page 446, there is a special provision concerning the method of estimating the actual cost of the work and the time in which it should fairly be expected to reach completion. This provision actually makes the contract a great gamble, bigger than anything ever before proposed, and one that can be made unfair to either the government or the contractor without much exertion. It is probably this great game of chance that has made the National City Bank of New York, the Standard Oil bank, acknowledge that it long ago laid its plans for financing whatever association of contractors takes the work; the managers of that institution have seen that the profits of the work are to be determined, not by the contractor or by the engineer of the undertaking, but by five experts who fix the "total reasonable cost of completing the construction of the canal" and "the reasonable time for the construction of the canal with the facilities afforded to the contractor under the terms of the contract." If these experts, who must reach their decision early in the life of the contract, fix a small cost and a short time, then the contractor's profits will be small, and he will stand a good show of being penalized in a considerable sum, particularly as the work must be done under government inspection, which always makes the cost about 10 per cent. greater than for the same grade of work for private parties whose inspectors are not tied down by red tape. If the experts estimate the cost of the canal at a good high figure and assign a liberal time for the completion of the work, it is manifest that the profits of the contract will be large.

On this basis, the crucial feature of the contract as a profit-making undertaking is seen to lie in the selection of the five experts who are to make the official and binding guess as to the cost and time of construction of a work on which the eminent men on the Board of Consulting Engineers reached such discordant opinions. One of these five men, who will be the chairman at their deliberations, is to be the chief engineer of the Isthmian Canal Commission, two others will be nominated by the Commission within ten days of the signing of the contract, and two more will be nominated by the contractor. It is manifest that this is the feature of the undertaking in which a great bank, a past master in financial diplomacy, and the banking representative of the most powerful financial interests in the country and probably in the world, sees an opportunity for exercising its finesse and tremendous influence. On the face of the contract, the government has three experts to two for the contractor, but as a matter of fact these experts will all unquestionably endeavor to reach a just decision in the momentus question they must settle. It goes without saying that men of the calibre selected for these grave duties will be of the highest professional standing and wholly beyond the reach of any influence tending to warp their judgment. It must be said, however, that a private company of great influence can doubtless secure the appointment of four experts whose estimates of the cost and time of construction of the canal will be 50 per cent. greater than the estimate of four men of equal professional experience and standing. The truth of this observation can be seen by comparing the various estimates made from the same data by the majority and minority of the Board of Consulting Engineers and by some of the witnesses before the Senate Committee on Interoceanic Canals.

Most experienced contractors will doubtless agree that in its spirit the form of contract proposed is admirable, but it may be doubted whether the method proposed for estimating the cost and time of construction of the canal is properly drawn to prevent a serious waste of public money. The shrewd psychologists and master diplomats in the world of high finance can simply play hob with any such arrangement for determining the crux of the contract, from a monetary point of view. It would have been far better to fix the time and cost before calling for bids, having these estimates prepared by the engineering staff of the Commission.

Faithfully yours,

Washington, Oct. 22. Joseph Jackson.

A Good Highway between Baltimore and Washington has been planned by the Maryland Highway Commission, and portions of it are now under contract. On these sections the available driveway will be 24 ft. wide, of which 14 ft. will be macadamized.